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ACADEMIC FREEDOM: ITS WORLD-WIDE SIGNIFICANCE

AT the seventh Quinquennial Congress of Universities of the British Commonwealth at Cambridge last July, which opened with a discussion on the relations which should exist between governments and universities, and at the International Congress on Science and Freedom held at Hamburg later the same month, warm tributes were paid to the University Grants Committee as a model for the distribution of government subsidies to universities. However, Dr. H. W. Dodds, president of Princeton University, indicated that the device is unsuitable for the universities of the United States, where its introduction would almost certainly expose the universities to undesirable pressures which are not experienced in Great Britain. He is of opinion that political, psychological and constitutional reasons make it unlikely that grants could be made unconditionally in the United States.

On the other hand, Dr. E. G. Malherbe, principal and vice-chancellor of the University of Natal, warmly advocated the application of this device to the finance of the South African universities, and it appears from the report of the Holloway Commission, tabled in Cape Town last summer, that this is likely to be done. The Commission was appointed in August 1951 as a result of widespread dissatisfaction with existing university salaries and with the present rigid and inelastic State subsidization, which had, in fact, broken down. The Commission holds that to enable the universities to fulfil their functions they require not only more money, with safeguards to the State against unrestricted financial obligations, but also greater freedom. The idea of attaching strings to the subsidies by regulations for State control was rejected by the Commission, which suggested an independent University Grants Committee, mainly to administer specially voted funds for research, but also to inspect the work of the universities, to watch over their development and to advise the Minister of Education on their financial needs.

These proposals, on which the South African Government has yet to announce its decisions, differ in some respects, which may prove important, from the arrangements for the University Grants Committee in Great Britain, and the significance of these differences may perhaps be seen in remarks which Prof. W. H. Hutt, of Cape Town, made at the Universities Congress. Prof. Hutt pointed out that in order to defend their independence when they are dependent on Government finance, universities have to weigh what they do and say in the light of their responsibilities, and they have to work together. This is not easy in South Africa, where the penetration of politics into university affairs now prevents Afrikaans and English universities from co-operating fully. Indeed, it is doubtful whether the conditions in which a University Grants Committee could function exist there, any more than in the United States.

Although this specific issue was not discussed at the International Congress on Science and Freedom

held at Hamburg, that Congress threw some light on the general principles which should govern the relations between governments and universities. To academic freedom, as to science, the most obvious danger comes with the enforcement of some extra-scientific or extra-academic canon of orthodoxy. Scientific advance and the functioning of the university are alike hindered when governments intervene indiscreetly and usurp or abolish the self-direction of university or scientist. The danger can arise not merely ideologically but also out of the utilitarian demands of the government making the grants. In Great Britain, apart from the discontinuance of the ear-marked grant, the Government has shown a most marked respect for university autonomy, as may be seen, for example, in the Treasury's latest reply to the recommendation of the Committee of Public Accounts that the books and accounts of the universities relating to expenditure of non-recurrent grants should be open to inspection by the Comptroller and Auditor General. Elsewhere, however, there is perhaps more danger that, in the legitimate initiation of projects in applied or fundamental research, governments may be less careful to avoid monopolizing them or allowing the objectives of their general policy to absorb too much of the available resources of the universities.

One of the essential conditions of scientific advance is that the scientist should have the freedom and resources to follow his own bent; and universities make their contribution to the advancement of learning, whether by teaching or research, under like conditions. When governments seek to order, instead of to foster, scientific or other creative activity, frustration sooner or later results. The first lesson a government has to learn in respect of the advancement of knowledge is to leave well alone, to see that the universities, the learned societies and scientific institutions and the individual scientists are not denied the necessary resources, and then to give them their head.

Prof. Ludwig Raiser, in an address at the Hamburg Congress on State support of universities and academic freedom, attached little significance to any audit by the State of the accounts of such an institution as the University Grants Committee, on the ground that the academic body itself would be no less concerned than the State to ensure the soundness of its accounts. He recognized, however, the importance of any such body as the University Grants Committee possessing the status enabling it to deal with the State on relatively equal terms, and to undertake the distribution of its funds expertly and impartially in a way that cannot be affected by any external pressure or sectional interests. Given such conditions, Prof. Raiser believes that financial support from the State will not prejudice academic freedom.

Such conditions, he recognized, are not universal even in the democratic countries. That they do not exist in the United States, for example, is one reason why the device of a University Grants Committee is regarded as unsuitable for introduction there. It would appear, moreover, that even if there were achieved the general public understanding of the essential character of the relations between the universities and the State which it is intended to serve, application of the device in the United States would still be unsuitable. Nevertheless, in the United States as elsewhere, the public has to be convinced of the decisive importance of academic freedom both for the national welfare and for the advancement of science; otherwise the universities, scientific institutions, learned societies and professional associations are likely to be handicapped seriously in their work by the forces and passions released under loyalty–security investigations.

Dr. J. D. Millett, president of Miami University, described the problem as that of giving reality to the ideals of a free society, and said that the crucial issue of our time is the discovery and invention of satisfactory practices for enabling universities to do their work while maintaining their vital characteristics as centres of unhampered intellectual endeavour. These practices will necessarily vary from one society to another; dangers acute in one community may be less serious in another, where other factors may present a much greater threat to academic autonomy. Moreover, even in the academic world, there is the danger to which Prof. Jean Thibaud, of the University of Lyons, directed attention, that the age-factor itself may militate against a sufficiently adventurous administration of funds for the advancement of learning. Seniority may avoid the danger of indoctrination to which the entrusting of authority to younger people is liable, but it may itself fail to be sufficiently adventurous or receptive to new ideas, and such reluctance is usually accentuated if the administrative body is a government organization.

The great dangers of centralization were thus amply emphasized at the Hamburg Congress, and there was universal agreement that no central authority should have the right to dictate or to restrict the objectives of academic inquiry. Even more welcome, however, is the evidence in the United States, in the Commonwealth of Australia, in the Union of South Africa and in Japan that attempts to interfere with academic freedom—of investigation or of teaching—are meeting with vigorous protest and opposition. Resistance to such interference can scarcely fail to be strengthened by the exposition of general principles at the Hamburg Congress and the evidence of uniformity of world opinion on the issues at stake.

As Prof. M. Polanyi pointed out, when the State establishes institutions for the cultivation of science, it recognizes a realm of independent ideas and independent men. It admits that the requirements of this realm may demand consideration on an equal footing with the political and material interests of the society it guards, and by implication the State accepts also the obligation to foster the advancement of this realm under the guidance of recognized academic leaders. Academic freedom, as a principle for the efficient organization of the advancement of science, implies the right of independent thought, and Polanyi rightly insisted that for its defence and re-establishment to-day in the face of a more penetrating and comprehensive critique of its

foundations, liberty must be formulated in more concrete terms.

The situation in the universities in South Africa, where the threat to academic independence is much sharper than in Australia, illustrates the point admirably. At present there are about 240 non-European students at the University of the Witwatersrand out of a total of about 4,000, and some 219 non-Europeans at the University of Cape Town; the 222 non-European students at the University of Natal receive tuition in separate buildings and never come in contact with Europeans. Apart from one or two small teacher training colleges, the only other institution of higher learning in South Africa open to its 9 million non-Europeans (out of a total population of 12 millions) is the University College of Fort Hare, and of the 17,500 students in South Africa, only about 1,160 are non-Europeans.

The recent Commission on Higher Education for Africans in Central Africa, where the disparity in numbers between European and non-European population is even more marked, observed that an institution of university rank is an essential possession of a community which has reached a certain stage of development and has a sufficient population and adequate resources; and that although the number of university-trained Africans now employed in the Rhodesias and Nyasaland is small, it would be wrong to conclude that the need for such Africans is limited. Nevertheless, hitherto in South Africa only the Universities of Cape Town and the Witwatersrand have conformed to the essential university tradition that no regard should be had to race, religion or class when selecting candidates for admission. It is not contrary to university practice, as the Carr–Saunders Commission points out, to reserve certain halls of residence or hostels for particular classes of student; but it would be repugnant to university tradition deliberately to place hostels so reserved at a greater distance than other hostels from the centre of the university. The segregation of particular classes in separate buildings for tuition, as in the University of Natal, is a manifest breach of tradition.

The stress which the Commission laid in its report on these matters may appropriately be recalled here. No test of religious or political belief was to be imposed as a condition of becoming a member of the staff or a student at the proposed University of Rhodesia, and the effective autonomy of the University and the independence of its multi-racial basis of any political or other external pressure were emphasized. In South Africa, however, not only has it now become apparent that the *apartheid* policy of the Government does not imply, as has primarily been contended, the gradual extension of higher educational facilities for all racial sections: it has also become clear that there is no intention of providing equal facilities for non-Europeans, and that the transfer of non-European education from the Minister of Education to the Minister of Native Affairs presages an attempt to carry the principle of discrimination and segregation from top to bottom of the field of education.

In this situation the attacks continually made since 1948 on the Universities of Cape Town and the Witwatersrand, where there is a policy of non-segregation, by members of the Government and others, have now begun seriously to threaten the autonomy of these Universities. During the last session of the Union Parliament, the Minister of Education announced that the Cabinet would consider the problem of university *apartheid* during the recess, and expressed the hope that the universities would co-operate in ending what he termed an intolerable position. While he disclaimed any intention of threatening the academic freedom of the universities, when pressed on the point in Parliament, he denied that this would prevent the Government intervening on the colour question, and in September last a Government newspaper stated that there was every reason to suppose that the Government was firmly determined to come to the next session with the necessary legislation if the universities were not prepared to take the necessary steps themselves. Furthermore, the Union Government has already, on December 18, 1953, proclaimed a Commission "To investigate and report on the practicability and financial implications of providing separate training facilities for non-Europeans at universities".

It appears to be improbable that the Union Government will secure the voluntary co-operation of the two Universities in question. The Council of the University of the Witwatersrand recently affirmed the existing policy of the University, and the acting principal of the University of Cape Town, Prof. W. R. James, after expressing the view that the evil results of allowing European and non-European students to attend the same classes were wholly imaginary, said that if *apartheid* was enforced by legislation the University would presumably obey; but that it would be most unwilling to lose a freedom enjoyed by nearly all the great universities of the world. The National Union of South African Students, the 11,000 members of which are drawn mostly from the English-speaking universities, has taken a strong stand in defence of non-segregation and university autonomy, and in conjunction with the Students' Representative Councils of both universities is doing what it can to combat Government interference.

On February 15 a statement protesting at the projected extension of racial segregation in the South African universities was issued by the Bishop of Johannesburg and twenty other signatories. Questioning the need for interfering with existing practice in the open Universities of Cape Town and the Witwatersrand, and denying that friction or internal tensions have arisen through the open system, the statement declares that a university must be free to attract the most able students in every racial group, to welcome independence of outlook and to promote the fruitful interaction of mind upon mind. The very existence of the two open universities, it argues, has enhanced South Africa's reputation overseas and given concrete expression to the desire for goodwill between Europeans and non-Europeans. To destroy the open system and replace it with complete, or even with internal, segregation would destroy one

of the last bastions of tolerance and enlightenment in South Africa and drive bitterness and despair into the heart and mind of the non-European.

An independent and informed observer may well reflect that, when all allowance is made for the natural irritation of a government at the opposition, perhaps not always tactfully expressed, of student bodies to its policy and proposals, the open universities of South Africa in their resistance to the imposition of *apartheid* from outside are fulfilling the same functions that the medieval universities, and especially the University of Paris, once exercised in Europe. Even when no restrictions are placed on the Press, on the platform or on the polling booth or ballot box, a body of educated men, such as a university faculty, have an essential function to play in a free society; nor can they continue to test, criticize and re-assess existing institutions and beliefs, approving or disapproving in the light of the evidence available, unless their independence matches that responsibility. In the democratic State of to-day, with so much tendency towards centralization, this function of criticism and discussion by independent groups and associations is vital to the preservation of freedom of utterance, of thought and of association, and for the prevention of the transition, by an insidious process of attrition, of a democratic into a totalitarian regime. No university can tolerate such interference as is now threatened in South Africa without losing its soul, and university teachers, officials and students will have the respect and support of their colleagues elsewhere in the Commonwealth if they show something of the turbulence of the old medieval universities when academic privileges and rights were invaded.

We are not considering here the general question of segregation or *apartheid* in South Africa. The rest of the Commonwealth may regret a decision in that sense, may think it mistaken, and may even have to pay a heavy price for it; but the decision is one for South Africa to take. What is no less true is that if segregation is to be adopted as a policy in the open universities, it must be on their own free decision, as a result of reasoned argument and the balancing of pros and cons, and not at the external dictation of Government or even Parliament. Once university autonomy is thus infringed, the value of the university as an independent centre of informed impartial criticism disappears.

Neither the Universities Congress nor the Congress on Science and Freedom can have left the Government of South Africa in any doubt as to the absence of sympathy for any such inroads into academic freedom as are threatened. A modern community, however, has such imperative need of independent centres of reflexion, criticism and judgment that it is not too much to hope that wiser counsels will yet prevail. As Lord Lindsay once emphasized, the universities and the churches have an essential part to play in preventing the disintegration of a community in the modern world. Their freedom and functions are not merely the remnants of a medieval tradition. The freedom of the modern university, Mr. R. M. Hutchins, formerly chancellor of the University of Chicago, has rightly said, is based on the proposition that societies require centres of independent thought and criticism if they are even to survive, and the function cannot be exercised unless freedom is guaranteed. The independence of thought that proceeds in a true university is thus too important to be curbed, even if it leads on occasion to the expression of reasoned views which are unpopular with a government or with particular groups or sections of a community.

How valuable that function of reflexion, discussion and criticism, and of social and educational experiment could be in the African world to-day is apparent from such a book as Prof. S. H. Frankel's "The Economic Impact on Under-developed Societies"*. Bringing out the complexity of the human and social problems involved in technical change, Prof. Frankel insists on the urgent need for a continent-wide study of these questions in Africa. In problems of human relations there are no easy or final solutions, and for solutions which offer hope of avoiding disintegration to be accepted they must be based on inquiry and study, the integrity and impartiality of which command confidence. Once confidence in the ability of a university institution to undertake such studies impartially and objectively is undermined, the basis of co-operation is destroyed. The Union Government might well reflect that hasty interference with academic freedom may destroy both the foundations of social order and one of the last hopes of averting racial disaster in Africa.

* The Economic Impact on Under-developed Societies. By Prof. S. H. Frankel. Pp. viii+179. (Oxford: Basil Blackwell, 1953.) 15*s.*

RESEARCH IN SCHISTOSOMIASIS AND ITS VECTORS

MIYAIRI'S discovery of the life-cycle of the fluke *Schistosoma japonicum* in 1913 raised hopes that the diseases caused by it and its allies might be controllable through their intermediate snail-hosts. These hopes were strengthened by Prof. R. T. Leiper's classical work in Egypt in 1915 on *S. haematobium* and *S. mansoni*; but, unfortunately, this early promise has not been completely fulfilled, and schistosomiasis remains one of the more intractable of tropical diseases.

It was assumed that a knowledge of the habits and ecology of the vector snails, once their identity had been established, might reveal stages in the cycle where mechanical, chemical, or biological control would be practicable. This assumption is probably sound; but the difficulties that have arisen have been mainly in connexion with the essential first step, which is to establish the identities of the vectors. Despite the vast amount of work that has been done on gastropod shells (under the urge of palæontological necessity and nineteenth-century fashion), relatively little attention has been paid to the snails that inhabit the shells, and it has become abundantly clear that the conchologists' 'species' are not recognized by the parasites. It also seems likely that

the ability to acquire and transmit schistosome infection is not a constant character even of a true biological species, but may be influenced by other factors, some environmental and some associated with infra-specific categories both of host and parasite. The problems are essentially biological, and the attack on them requires the closest collaboration between workers in different fields—experimentalists, ecologists and, especially, malacological taxonomists.

Since the disease is widespread, it is appropriate that the World Health Organization should co-ordinate national efforts and, to this end, a preliminary conference was recently held in Paris to compare notes on the taxonomic position and to discuss future research. The meeting was mainly concerned with the disease in Africa, and, as a major Colonial power in that continent, Britain is intimately concerned; but, unfortunately, it possesses no zoological organization whose normal responsibilities cover the whole field and which has all the necessary facilities.

Much of the work clearly falls within the scope of the British Museum (Natural History), which is acutely aware of the importance to medicine and animal husbandry of a more intensive study of the taxonomy of helminths and their vectors. Modern taxonomy requires, for the recognition of natural species, as complete a knowledge as can be obtained of the full extent of variation of all populations that can be shown to be normally interbreeding. Furthermore, taxonomy requires this knowledge over the whole range of environmental conditions under which the animals can, and do, exist. The same knowledge would also go a long way towards supplying the basic needs of those seeking for methods of control, and consequently the Colonial Medical Research Committee and the Museum are considering together suitable methods of providing research facilities. Inevitably financial consideration will limit the scope of their efforts.

In the circumstances, it is worth while directing the attention of biologists to the research fellowships which are being offered by the Civil Service Commission. Two classes of fellowships are offered: senior awards, of the value of £800–£1,000 a year, and junior awards, of the value of £500–£700, and the usual universities superannuation scheme applies to both. There is no age limit, but three years of post-graduate experience in research will be required of candidates seeking senior awards and two years of similar experience for junior awards. Fellowships are tenable for three years at a Government research establishment, "for research into subjects of importance to H.M. Government"—terms of award broad enough to cover the whole field of scientific endeavour. No doubt consideration would be given to the biological aspects of schistosomiasis and its vectors if candidates of suitable qualifications come forward. The problem is of outstanding importance from the points of view of both human affairs and biology, and it is to be hoped that this opportunity of advancing knowledge will be seized without delay.

A PIONEER OF MICROBIOLOGICAL EXPERIMENT

Abraham Trembley of Geneva

Scientist and Philosopher, 1710–1784. By Dr. John R. Baker. Pp. xix + 259. (London: Edward Arnold and Co., 1952.) 35*s*. net.

THE lives and achievements of eminent scientific men have been, in general, well explored. Thus the biography of science tends, more and more, to works on lesser figures. It is therefore refreshing to encounter a careful study of a neglected yet highly distinguished exponent of scientific method. Dr. J. R. Baker is well known both as a cytologist and as the historian of the cell theory, quite apart from his editorship of the *Quarterly Journal of Microscopical Science* and his philosophical writings on freedom in science. He is indeed peculiarly well equipped for investigating the life-work of Trembley, to which he has devoted much care and skill. This most readable book is not likely to be superseded.

Not only students of biological history but also many of those who love beautiful books for their own sake know Trembley's "Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes" (Leyden, 1744). It is famous both for its admirable plates, drawn and engraved by Trembley's friend, Pieter Lyonet (1707–89)—one of the most skilled micro-anatomists of all time—and for its exquisite vignettes of the gardens and house in Holland where Trembley lived and worked during his most productive years. His achievements are most attractively presented by Dr. Baker in their scientific and social backgrounds.

Trembley was essentially an experimental physiologist who studied a few organisms, but those intensively. Such naturalists were rare in the century dominated by Linnæus (1707–78), who sought to survey ever larger and larger numbers of species, to arrange them and to find patterns common among them. Of the physiological and intensive type of naturalist three contemporaries stand out pre-eminently—Trembley, Lyonet and, above all, de Réaumur (1683–1757). The three were in such close association that Dr. Baker has often to consider them together. For Trembley he makes the following claims, which we set out, almost in Dr. Baker's own words, though a little qualified here and there.

(1) He was the first serious student of animal reproduction by budding, the first to prove experimentally that the process is asexual, and the first to discover that budding of new individuals occurs in animals other than hydra and notably in Polyzoa and Annelida.

(2) He was the first to show that certain animals can be artificially multiplied by division and the first to make a single individual by grafting two animals together. Dr. Baker's additional claim that Trembley was the first to make permanent grafts of animal tissue should perhaps be reconsidered with reference to Tagliacozzi (1546–99) and certain even earlier workers.

(3) He discovered that Protozoa multiply by division, and form colonies when the division is not quite complete; he was among the first to witness cell-division and certainly the first to see it in a single-celled alga.

(4) He described some of the salient physical characters of protoplasm, 101 years before Dujardin.

(5) He was the first to describe the anatomy of a polyzoan. The general recognition of the animal nature of Polyzoa and sessile cœlenterates was largely due to him.

(6) Of techniques, he introduced that of vital dyeing. He also adopted an injection process in which the colouring matter was forced through the body cavities by the animal's own muscular movements, thus demonstrating that the tentacles were hollow, their cavities being continuous with the main cœlenteron.

His best-known achievements are, of course, his intensive study of the structure, habits, life-history, and methods of reproduction of *Hydra* and his extraordinarily skilled experiments with several species of this creature. For all of them he used no more than the most elementary apparatus. His microscopes were single lenses of very short focal length, each carefully mounted in a metal disk and held by a metal rod divided into segments by a series of universal joints. Trembley, like his friends Lyonet and Réaumur, was above everything a reliable and resourceful observer. He had a temperamental objection to hypothesis. Excess of caution has its nemesis, and these great observers, unlike their less cautious contemporaries, Buffon (1707–88) and Bonnet (1720–93), failed to find successors or to found schools of thought. Trembley was far from a voluminous writer, and Dr. Baker's careful bibliography contains only twenty-eight items, which include his philosophical, educational and religious works, together with reprints, reviews and contributions to journals. Few great naturalists have written so little and that little so good. Dr. Baker's book has a model index. It contains, under the heading 'Trembley, Abraham', a convenient chronological epitome of his life. In general, the biographical details are interwoven with the scientific with unusual skill. The book is beautifully illustrated and produced and is not expensive, as the prices of such things rule nowadays.

Charles Singer

USE AND THEORY OF MATHEMATICAL ANALYSIS

Differential Equations

By Robert C. Yates. Pp. vii+215. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 32*s*.

Advanced Mathematics in Physics and Engineering

By Prof. Arthur Bronwell. Pp. xvi+475. (London: McGraw-Hill Publishing Co., Ltd., 1953.) 51*s*.

Complex Analysis

An Introduction to the Theory of Analytic Functions of One Complex Variable. By Prof. Lars V. Ahlfors. (International Series in Pure and Applied Mathematics.) Pp. xi+247. (London: McGraw-Hill Publishing Co., Ltd., 1953.) 42*s*. 6*d*.

IN "Differential Equations", by Mr. R. C. Yates, of the United States Military Academy, West Point, a first course in differential equations is presented, suitable for the student of physics or technology; it covers the explicit solution of elementary first- and second-order equations, and includes brief introductions to the formalities of solution in series, Legendre and Bessel functions, simple partial differential equations and Fourier analysis. The numerical methods of Runge-Kutta and Picard are given a short chapter. The author is well aware that the mathematician may cavil at the omission of existence theorems, convergence of series, and other matters of logical importance; but he is thinking primarily of the user and is content to refer to more advanced texts for these refinements. For students in the Armed Services, the need to relate mathematical methods to Service problems is over-riding; and here Mr. Yates serves his readers well, since in most instances a new topic is introduced by means of particular and concrete problems, and the number of exercises for the student is ample. Moreover, Chapters 4, 8, 11, 15 and 19 bear the title "Summary and Review Problems", and in these the student can find an epitome of the preceding work and a further collection of relevant exercises. Perhaps Chapter 13, on Legendre and Bessel equations, should have been placed after Chapters 16 and 17 on partial differential equations, since then the bald statement that these are "two of the most important differential equations that occur in mathematical physics and engineering design" could be made more readily acceptable to the novice; but this is a very small blemish on a pleasant and useful introduction to a subject of high technical importance.

Prof. Arthur Bronwell is professor of electrical engineering in the North-Western University, Evanston, Ill.; naturally, his interests are on the technical side, and his volume, "Advanced Mathematics in Physics and Engineering", could be used as a sequel to that of Mr. Yates. His task is, however, more difficult, since he wishes not only to expound mathematical methods, such as infinite series, differential equations, vector analysis, Fourier series, complex variable and Laplace transform, but also to use these in an account of dynamics, circuit theory, heat flow, hydrodynamics and electromagnetic theory. Five hundred pages is perhaps too short for so vast a design, yet the chapters on these physical applications, while compact, are not obscure, though in one or two places more stress on the physical bases would have been helpful. The purely mathematical chapters do not appear to have received so much care in their construction; there are many loose and casual statements, while in the earlier paragraphs of Chapter 2 (complex numbers) and Chapter 10 (vector analysis) it is extremely difficult—and the novice might well find it impossible—to determine what is definition and what is inference. The notion that the technician need not understand a method so long as he can use it is antiquated; the really powerful mathematical tools must be understood in order to be efficiently used. Prof. Bronwell's massive compendium shows the use of many of these tools, but for a full understanding the reader should supplement accounts here given by referring to some of the authoritative texts mentioned in the chapter bibliographies.

As befits a pupil of Ernst Lindelöf's, Prof. L. V. Ahlfors writes for the mathematician. In "Complex Analysis" his topic is classical, though he has been able to find room for some fairly recent additions, notably subharmonic functions and Perron's method for solving Dirichlet's problem. There are, however, novelties of exposition. The student is not hastily presented with Cauchy's theorem; in fact, this does not appear until p. 88, and then only for a rectangle and a circle, the general theorem coming twenty pages later. Very wisely, the way is prepared by a thorough study of simple topological notions, and

by considerable attention to elementary conformal mappings. Good in itself, this study prepares the reader for the two-fold aspect, topological and analytical, of Cauchy's theorem, where Artin's ideas make for comparative simplicity. In effect, Prof. Ahlfors cuts the topology of the subject to the minimum and then gives that minimum with the utmost clarity and precision. The calculus of residues receives meagre treatment: it is off the main line, and Lindelöf's own beautiful monograph is easy to obtain. Elliptic functions are excluded, Prof. Ahlfors expressly referring the reader to Copson's classical book on the complex variable. Space thus saved is given to two chapters, one on the recent work referred to above, and the other to the theory of multiply-valued functions, which is clear enough as an introduction but scarcely goes far enough to be either satisfying or provocative; twenty pages more here might have explored the main foundations of algebraic functions. In all, this is a clear, authoritative, up-to-date treatise, thoroughly suitable for the undergraduate beginning to specialize in function theory.

OCCURRENCE OF PETROLEUM IN THE EASTERN HEMISPHERE

The World's Oilfields

The Eastern Hemisphere. Editor: Prof. V. C. Illing. (The Science of Petroleum, Vol. 6, Part 1.) Pp. viii + 174. (London, New York and Toronto: Oxford University Press, 1953.) 52*s*. 6*d*. net.

LIKE the previous addenda to "The Science of Petroleum", this is a very fine book. Written by a selection of contributors, each vessel in a particular terrain, it deals with the subject as a whole and forms a work of reference limited only by the knowledge available at the time of writing. Therein, as is natural, may lie a few limitations. So far as petroleum at present is concerned, the "Eastern Hemisphere" is chiefly Europe and the Middle East. In the case of Europe, information that is, or has been, readily accessible (such as that regarding Germany, Poland and Roumania) is already fairly well known; what has not been accessible and was mostly unknown when volume 1 of "The Science of Petroleum" was published in 1938 (for example, developments in Austria and Hungary) includes the more important new fields largely developed subsequent to the outbreak of the Second World War and still behind the Iron Curtain. The result is that in these sections, where knowledge of production is sparse, the treatment seems rather heavily weighted on the side of general geology. This is so, to some extent, even with the important fields of the Middle East, on which however, by reason of their broader outlook, the articles by Lees are refreshing to read. Although oilfields are sub-surface affairs, it is natural that exploration, their discovery, delimitation, development and handling of production should be of the widest interest. One is consequently apt to miss the treatment in Vol. 1, wherein a single part of discussion of individual oilfields was in proportion to some five parts of the general aspects of production concerned with geophysics, siting, drilling, field-engineering and transportation.

The present volume is therefore of greatest importance to students and workers in the field of petroleum geology. The pattern of treatment in the sub-sections is to follow a short introduction with details of the stratigraphy and tectonics of the area concerned. The oil-source rocks are then discussed separately. Good use is made throughout of effective tabulation, and maps and diagrams are excellent. The sections dealing with the Far East and Australasia, and with Africa, contain articles by fourteen separate authors. They vary in length; but the majority, though short, succeed in giving general outlines of the oil geology of the extensive but not very productive areas concerned. In this way, the implications of subsequently acquired information or discovery afterwards made can readily be fitted in.

Prof. Illing and his contributors are to be congratulated on producing a volume which will be of permanent value in the study of the occurrence of petroleum.

S. J. M. AULD

MARGINAL LAND IN BRITAIN

Marginal Land in Britain

By Prof. W. Ellison. Pp. 224 + 16 plates. (London: Geoffrey Bles, 1953.) 25*s*. net.

PUBLIC attention has been directed repeatedly in Great Britain to the possibilities of marginal land improvement during the past ten years or so, and the absence of any comprehensive book on the subject has meant a substantial gap in agricultural literature. This gap is now filled very adequately by Prof. W. Ellison's book. It cannot be easy to write a book which will be read with interest and profit by both the farmer, on one hand, and the scientist and administrator on the other. Prof. Ellison, we know, is an enthusiast for reclamation and rehabilitation of the land and farmsteads of British uplands; but unlike so many agricultural enthusiasts before him, he has been content to give an ungarnished factual account of the nature and extent of the problem, drawing on his own and other people's practical experience to show with facts and figures how production can be increased from this type of land, and at what cost. It is a great merit of the book that the agricultural problem of marginal land in the uplands is always kept in perspective, both in relation to its alternative use for forestry and water-gathering grounds, and to the needs of the lowland farmer upon whom the upland farmer so largely depends.

The book begins with a historical introduction and goes on to describe the findings of the various committees which have considered the problem in recent years. The different types of marginal land in Great Britain are defined and delineated on folding maps. There follow valuable sections on the methods of improvement appropriate to these different types and on the utilization of the resulting increase in production of crops and grass. The author's discussion of the extent to which, in the uplands, rehabilitation of the farm-houses, buildings, roads and services must accompany improvement to the land is based on actual surveys, which emphasize the high capital costs involved.

If there is an omission from this otherwise well-balanced book, it is perhaps the relatively slight reference to the personal factors in this problem—the labour force (family and hired); the landlord; and, most important, the abilities and shortcomings of the farmer himself.

THE AMATEUR SCIENTIST IN BRITAIN (I)

By R. BRIGHTMAN

IN his presidential address to the British Association at Liverpool in September, "speaking as a professional scientist who has only recently turned amateur", Sir Edward Appleton made generous acknowledgment of the immeasurable debt which science owes to the amateur scientist. This welcome tribute was supported, moreover, by others at Liverpool, notably at the Assembly of Corresponding Societies when Dr. P. M. Butler, for example, referring to the work of amateur naturalists in Lancashire, particularly in botany, and especially around Manchester and Oldham early in the nineteenth century, pointed out that before 1850 some of these amateurs had an international reputation, especially in the study of mosses. An account of the work of some of these men was given by Mr. J. Cash in his book "Where There's a Will There's a Way", published in 1873[1]. The tradition persisted well into this century. Mr. F. E. Milsom, for example, a chemist who died in December 1945, after many years service at Huddersfield in the British Dyestuffs Corporation and the Dyestuffs Division of Imperial Chemical Industries, Ltd., had an international reputation for his study of the bryophytes, and particularly the hepatics; from 1934 he was the referee of the British Bryological Society for British and European hepatics, and he also was an authority on the mosses.

Nevertheless, for the past half-century or so many comments have been made on the decline of the amateur in science, both in numbers and importance. In his presidential address to the British Association at York in 1906[2], Prof. E. Ray Lankester, for example, regretting this decline, remarked that the field naturalists seemed then not to be so numerous and active as formerly, and suggested that the organization and professional character of scientific work were to a large extent the cause of this decline in its attraction for the amateur. His comment that the mechanics' institutes and lecture societies of the days of Lord Brougham had given place to a very large extent to other entertainments, more diverting, but not really more capable of giving pleasure than those in which science was popularized, and that the decadence was also "due in some measure to the increased general demand for a kind of manufactured gaiety, readily sent out in these days of easy transport from the great centres of fashionable amusement to the provinces and rural districts", has a very topical ring.

In the following year, Prof. H. B. Dixon, in a presidential address to the Manchester Literary and Philosophical Society[3], deplored in particular the belief that professional men of science were jealous of the amateur, and by a conspiracy of silence or contempt sought to obscure his merits and so maintain their prestige. Prof. Dixon quoted in this address from a farewell letter written by Dr. Edmund Schunck to the Society some years earlier deploring the increase of the professional element and the disappearance of the amateur from membership of the Society, and making an impressive plea for the cultivation of the amateur in science. The amateur, Prof. Dixon urged, possessed patience, skill and enthusiasm and the advantage of an open mind. He could bring to discussion a freshness of ideas which more than compensated for any possible defects of critical judgment. Prof. Dixon saw no reason in the nature of things why a professional in one science should not be a successful amateur in another. Probably no more stimulating ideas are struck than at the personal contact of two minds trained in different sciences.

A similar theme was pursued by Prof. H. A. Miers in addressing the Conference of Corresponding Societies at the British Association meeting in Dublin in 1908[4]. While in recent years opportunities for scientific education had expanded, at the same time the gulf between the amateur and the trained scientist had widened, and Prof. Miers was concerned with the possibility of bridging this gap through the work of the corresponding societies and in other ways. Even then it was, he said, more difficult for the amateur to get adequate insight of the recent advances of science without a course of special reading or without attempting to master treatises for which he required some kind of preliminary training. Moreover, the intelligent amateur no longer necessarily belonged to a class quite outside scientific circles as formerly, but was frequently quite learned in one branch of science though he may be the merest amateur in another. Yet when he travelled outside his own subject he was in danger of being placed in a position somewhat similar to that of his predecessor, the amateur of sixty years ago. Not only was the position of the amateur unsatisfactory in regard to scientific literature, but still more was it true as to the societies. The scientific societies were becoming highly specialized in their membership, and it was more difficult for even the intelligent amateur to gain anything from the proceedings and meetings of these societies. In this situation, which is more intense to-day, Prof. Miers thought that the best hope of improvement lay in the work of the local societies, and particularly in the sort of field-work which they could initiate, so that the professional and the amateur could find common ground. Anything, he urged, that tended to break down the barrier between the professional and amateur, between expert and layman, was for the good of scientific progress, and he referred in this connexion to a previous protest by Mr. Lamplugh, president of the Yorkshire Naturalists' Union, against the unhealthy distinction between amateur and professional and his plea for the amateur spirit in scientific work.

Nearly twenty years later, addressing the Conference of Delegates of Corresponding Societies at Oxford in 1926[5], Sir John Russell remarked that although the amateur with a few shillingsworth of apparatus was no longer able, in Faraday's words, "to make himself as considerable" as people with long specialized training working in well-equipped laboratories, the amateur who was prepared to take trouble still had his place in the advancement of knowledge. In the observational sciences—botany, geology, anthropology, archæology—he was able not only to interest himself but also to help others. Sir John proceeded then to discuss the scope which regional surveys offered for the activities and wide outlook of the amateur worker. Like other scientific

work such work was team-work, but such as the corresponding societies could do, usually, best in consultation with the professional workers of the university schools. A regional survey gave a survey of a district as an environment for human beings—an account of its physical features, its natural characteristics, its flora, fauna, etc., culminating in a study of the ways in which they affect human life and activity. It was this human aspect that gave the non-professional worker his opportunity, for his close touch with human affairs enabled him to appreciate and to express the human point of view.

Experience of the numerous regional surveys of recent years has amply confirmed the truth of Sir John Russell's remarks. Nevertheless, in spite of this and the long tradition of the amateur worker, particularly in botany, both Dr. R. S. Bates in his book, "Scientific Societies in the United States"[6], and Prof. A. D. Ritchie in a contribution to the symposium "Science, the Universities and the Modern Crisis" of the Manchester Literary and Philosophical Society, could note a tendency for the specialist to despise and ignore the amateur. Prof. Ritchie pointed out that there used to be an enlightened public of amateurs to which every specialist had to appeal to earn recognition. "Now," remarked Prof. Ritchie, "amateurs are unwanted, get snubbed if they interfere and have mostly died off."[7]

There is, however, now less danger of the amateur tradition in science dying out than there was in the early years of the century. Since the War there has been an encouraging increase in the activities of the amateur scientist, particularly in biology, in many countries. Notably in the United States, serious efforts are being made to foster the work of the amateur scientist, and to see how his contribution to the advance of science can be made most fruitful. This tendency is to be welcomed on several grounds. As the title alone of Dr. Dorothy Stimson's book "Scientists and Amateurs"[8] reminds us, the Royal Society began with amateurs. Even earlier than that date, as Canon C. E. Raven pointed out in his study of the making of the modern world, "English Naturalists from Neckam to Ray"[9], there were scientists who could be clearly described as amateurs. Indeed, in his more recent Gifford Lectures, "Natural Religion and Christian Theology"[10], Dr. Raven argued that Robert Hooke was the first professional scientist in Britain. Moreover, particularly in his book on the English naturalists, Raven insists that Bacon and those Christian thinkers who followed him and founded the Royal Society were not primarily concerned with the benefit of their discoveries to mankind. Their basic conviction was that from the accurate understanding of the Creation they could gain a true and effective knowledge of the Creator, and so could bring the life of mankind into a fuller and more intelligent correspondence with His will. They regarded theory and practice as inevitably interdependent. This appeal to factual evidence, to observation and experiment, marks, as Raven shows, a revolution in the method of philosophy which had prevailed until then, which is perhaps even more strikingly illustrated in the life and writings of the Norfolk doctor and naturalist, Sir Thomas Browne, best known for his "Religio Medici". The coming of this modern scientific outlook was, in fact, not just a succession of specialized workers, but was characterized by a general change in outlook among educated men, which is perhaps better appreciated when illustrated in ordinary men such as Sir Thomas Browne, rather than among those men of genius who were the effective leaders of the Royal Society during its first generation.

Both in this book and in his Herbert Spencer Lecture[11], Raven lays much stress on this aspect. These first scientists were not only men of deep religious conviction, but also were possessed of a genuine passion to see life steadily and to see it whole, and of a no less genuine belief that in studying the works of creation they were enlarging man's knowledge of the wisdom of God. Their motive was not solely utilitarian. They cared profoundly for the well-being of their fellows and the benefit which a truer knowledge and wise use of resources would bring. But they were also fascinated by the sheer interest of their explorations, and convinced that in the search for deeper understanding they had a worthy creative bond. That, I think, well expresses one reason why it is important to-day that the amateur tradition in science should be maintained. It is a corrective, as well as an inspiration, to science itself, apart altogether from its contribution to the atmosphere or climate of opinion in which alike the prosecution of scientific work and the application of its results are most fruitful.

Amateurs in science then, in the accepted sense of the word, denoting those that practice their art not as a livelihood, but for the love of it, were to be found in many places and in many classes of people in the latter part of the seventeenth century—mainly in circles sufficiently wealthy or leisured for its pursuit. The other period of this feature which may be noted here is that to which Ornestein directs attention—the way in which unions of scientific workers became the dominating feature of scientific work. They concentrated, he points out, groups of scientists at one place, who performed experiments and carried out investigations impossible to individuals. They encouraged individuals and gave them opportunity and leisure and financial support for scientific work, becoming centres of scientific information and publishing and translating books; they dispelled numerous popular errors and at times endeavoured to reach the general public by means of lectures. They were concerned with trade and commerce as well as science. To them also was due the development of the scientific laboratory, the creation of national observatories, and the standardization and improvement of instruments and technique.

Nor is it surprising to find that the amateur is equally prominent in the eighteenth century, and with, for example, clergymen like Stephen Hales or medical men like John Mayow, who made important contributions to our knowledge of the gases of the atmosphere. As F. Sherwood Taylor pointed out in a paper on "The Teaching of the Physical Sciences at the end of the Eighteenth Century"[12], almost the only scientific professions were those of the medical man and, to a less extent, the engineer, mechanical or military. The professional scientist, in to-day's sense of the word, scarcely existed until the nineteenth century was advanced.

What merits notice here is the way the amateur tradition persisted well into the nineteenth century even when the professional scientist had well established himself outside the ranks of the medical men or the engineers. It is less surprising that as the century opened Edward Jenner (1749–1823) should be scarcely more distinguished as the discoverer and pioneer of vaccination than as the naturalist who gave the first detailed and accurate account of the

eviction by the newly hatched cuckoo of the eggs and fledglings of the foster parents, and even communicated to the Royal Society just before his death important observations on the migration of birds. At the end of the century, however, we can point to Sir John Evans (born in the year of Jenner's death), the professional chemist and paper manufacturer whose amateur interest in geology and archæology won him as much distinction, including the fellowship of the Royal Society, as his original field of study. Sir Joseph Prestwich, with whom Sir John Evans was first associated in investigations of flint implements in old river gravels, was a wine merchant who took up geology as an amateur before he ultimately became a professional geologist and professor. Sir Charles Lyell, General Pitt-Rivers, Sir John Lubbock and Sir Norman Lockyer (the first editor of *Nature*) are others of the same period who first distinguished themselves in science as amateurs, and only in the latter part of their careers could Lyell or Lockyer be fairly described as professional geologist or astronomer.

The most important point, however, is brought out not so much by the fact that men trained in one profession or in one branch of science can make distinguished and important contributions to the advance of knowledge in quite another sphere which they took up for its own intrinsic interest to them. Particularly where it is a matter of two different scientific disciplines, it could then be argued that one serves as a basis for the other, and that we are concerned with transfer from one professional discipline to another rather than with a strictly amateur activity. The amateur aspect is none the less important, but its value is perhaps seen more clearly in the contributions which came, especially in the first half of the nineteenth century, from Hugh Miller, the journeyman mason of Cromarty, whose "Old Red Sandstone" is essentially the work of an amateur geologist, or the amateur naturalists of Lancashire already mentioned.

Sir John Maud also referred to this aspect in a recent address on the "University Graduate"[13]. Sir John referred to a characteristic which is very difficult to describe but which is of special value to-day, and he described it as the mark of the amateur in the best sense of the word—the amateur who does not claim to be a professional or an expert and who, where there is need of expert knowledge, knows that he must consult the professional, but also knows that having consulted him he may well be right not to take his advice; the amateur who loves his job, without sentimentality, and really enjoys his working hours so that there is no clear distinction between the good life as it is lived while he earns his livelihood, and the good life that is lived during his so-called leisure.

This outlook or quality of the amateur accordingly, quite apart from the direct contribution which the amateur scientist can make to the advancement of knowledge, is thus of value in correcting the fragmentation of modern life and in encouraging that wholeness of living which the modern world greatly needs. At the philosophical level it is unlikely that the amateur has any significant contribution to make, but at the practical level of human ecology, such as finds expression in the writings of Dr. K. E. Barlow and others, the multiplicity of amateur activity in varied fields of science could do much to restore sanity to civilization and encourage the receptivity which determines so largely the adjustment of society to a changing environment. In this connexion it is pertinent to recall that industry itself in the nineteenth century owed something to the amateur. W. Weldon, the journalist, whose interest in industrial chemistry led him to the discovery of the process bearing his name for the regeneration of manganese dioxide in chlorine manufacture, is perhaps the outstanding example. The discovery revolutionized the industry, and Weldon himself was elected a fellow of the Royal Society in 1882. Modern steel-making is founded upon three British inventions, all of which came from outside the industry. The Bessemer and Siemens' converter and open-hearth processes for making steel as it is known to-day both depended on the iron ore used being almost entirely free from phosphorus. The basic process which made phosphoric ores suitable for steel-making was invented by S. G. Thomas, a Metropolitan police court clerk; as a Middlesbrough ironmaster put it, "An amateur pressed it upon the ironmakers".

As has already been said, important contributions to scientific knowledge are still being made by amateur scientists in various fields. At the annual general meeting of the Edward Grey Institute of Field Ornithology, Oxford, on October 27, 1950, Dr. D. Lack, its director, referred to major advances in five fields of zoology in which the amateur naturalist as well as the professional zoologist had participated[14]. First, Prof. W. Rowan, speculating and later experimenting on the immediate factors causing birds to migrate, discovered that increased day-length can bring the sexual organs to maturity outside the normal breeding season, and even in midwinter. This has led to important advances in reproductive physiology, not only in birds but also in other vertebrates.

Secondly, the apparently trivial 'splitting' of the bird taxonomists eventually provided a firm basis of comparative material for the subspecies concept, which led in turn to the dramatic discovery of two subspecies of the same species (the great tit), living together in the same region and "behaving as good species".

Thirdly, the field-study of bird behaviour led first to a purely ornithological discovery, Eliot Howard's theory of territory, and later, assisted by observations on captive birds, to important new concepts concerning the nature of instinctive or innate behaviour in animals. The studies started by Lorenz and Tinbergen on birds have later been most profitably extended, particularly to fish and to insects.

Fourthly, bird-ringing has put the study of migration on a precise and quantitative basis, while the recent observations on visible migration and some spectacular results with homing experiments have renewed speculation on the method or methods by which birds find their way.

Finally, there is the new study of "population dynamics", or "population ecology". Through long-term censuses, the fluctuations in certain bird populations are more accurately known than those of any other animal. An unexpected by-product of the bird-ringing scheme has been to establish not only how long wild birds are capable of living, but also their average expectation of further life. The latter is far shorter than popularly believed—only about one year in the case of the robin, for example. The reproductive-rate of birds and the factors determining it have also been the subject of precise and quantitative study. Indeed, it should soon be possible to obtain a complete life-equation for a bird living under normal conditions, and this should help to advance the study of the factors which control population density in animals.

The co-operative field-work of the British Trust for Ornithology, which was founded in 1933 to maintain the field-work already started at the University of Oxford between the professional zoologist and the amateur, is of some interest in this connexion. It should be remembered, of course, that, as Mr. Bruce Campbell has pointed out[15], very similar co-operative methods were used by the British Association and by the British Ornithologists' Club in their studies of bird migration many years ago, and we may even see the germ of the idea in Gilbert White's circle of correspondents. In a co-operative inquiry, observers all over the country are linked together by a central organizer, to whom they send in their information, and who is responsible for drawing up the final report and for calling in expert advice as he requires it. It has been a feature of inquiries run by the Trust that the organizer has seldom been a professional zoologist, but that the inquiry has been agreed upon and the report submitted to a research or advisory scientific committee, on which sit both professional (*sensu stricto*) zoologists and men who have devoted the free hours of a lifetime to studying birds. Usually one or two members are particularly interested in each inquiry and keep in close touch with the organizer.

Careful choice of subject in such inquiries is, of course, required, and the manner in which it is conducted may also be modified. An organizer may conduct his inquiry through a limited group of correspondents of proved experience, or he may delegate to local organizers, who can sieve information in their own regions before sending it on to him. A good example of this is the ten-year census of the great-crested grebe, over a sample area mainly in the English Midlands, which began in 1946 as a follow-up to the original national survey of 1931.

The co-operative technique has not only been used for bird problems. In Monica Shorten's study of the status of the grey and red squirrels in Britain[16], a research worker at the Bureau of Animal Population, Oxford, corresponded with voluntary observers all over the country, while Sir William L. Taylor's surveys of the distribution of wild cats, capercaillie and wild deer on Forestry Commission area[17] have shown how the staff of a widespread organization can contribute useful data as a by-product of their main work.

The above contributions to zoology have been made partly by professional and partly by amateur naturalists. Both, it is scarcely necessary to add, are scientists. The cleavage imagined by some nature-writers to exist between the cold-blooded scientist and the warm-hearted amateur is, of course, a fiction. Thus the amateur scientist still continues to add materially to ornithology. Incidentally, it may be noted that in his book, "The Art of Scientific Investigation"[18], Prof. W. I. B. Beveridge remarks, "I have noticed that in England a great many research workers in both the biological and non-biological sciences are, or have been in their youth, keen naturalists. The pursuing of some branch of natural history as a hobby by a young man may be a valuable indication of an aptitude for research".

At the Birmingham meeting of the British Association, in a paper read to the Education Section, Dr. A. G. Lowndes quoted two instances of research carried out at schools in spite of the absence of costly apparatus[19]. A wave passing up a flagellum was first photographed, not at the University of Cambridge, but at Marlborough College. The myth that the egg of the dogfish consists of an enormous amount of yolk was not exposed and exploded at a university. The initial work was done at Rugby School during ordinary class teaching. A promising feature of recent years is, in fact, the extent to which opportunities are opening up for effective participation by young amateurs in scientific work. The observations on the natural history of starlings, recording the results of twenty-five years bird ringing at Bootham School, York, under the direction of Mr. Clifford J. Smith, is one example of activities which the British Trust for Ornithology has done much to foster during the past twenty years. The survey has shown that in winter we have starlings of two races in Britain: the residents that nest here and those that come from Europe but nest abroad and cannot interbreed with our native birds. Only a preliminary report is yet available, but it is hoped that much of the survey will be published in more permanent form.

Another example of what enterprise and imagination can do to demonstrate the nature of scientific work to the schoolboy and to provide opportunity of participating in the making of observations of value to science is to be seen in the oceanographic expedition to the North Sea organized early in 1953 for science sixth-form boys from the Watford Grammar School[20]. The expedition consisted of eleven boys and one master, and the party was distributed among the trawlers so that in each ship there was one boy who carried out the duties of a biologist and one who acted as chemist, physicist and meteorologist. The biologist was to collect otoliths and connect their age with their length and to investigate the stomach contents of as many fish as possible. The others were to study the trawl contents to gain information about the North Sea as it was in the last glaciation and during the subsequent emergence of dry land, and build up a complete picture of the conditions of North Sea fishing. The party obtained fifty-two samples of salt water and 130 sets of meteorological recordings, including surface temperature, relative humidity, wind, sea, swell and sounding and position and time.

The venture clearly has features in common with the expeditions of the British Schools Exploring Society, notably that to British Columbia in 1953, on which scientific work undertaken included the mapping of the region of the north-western arm of Lake Stuart[21]. Two bathymetric cross-sections undertaken showed interesting results relating to the general form of the lake basin. A main meteorological station was opened at base camp and regular observations were taken, and one team was concerned with the micro-meteorology of the forest trunk-space. Biologists on the expedition made collections of pressed plants and of lesser known insects from the deciduous and coniferous forests as well as from the alpine zone of the Mount Sydney Williams massif. Detailed notes of bird and animal life were also made.

Yet another instance is to be seen in the extensive survey of weather in the Cairngorms conducted in the summer of 1953 at five high-altitude weather stations by teams of undergraduates and senior schoolboys[22]. The practicability of camping in such tough conditions—three of the camps were at more than 3,000 ft.—was demonstrated in 1952 by a pilot expedition from the Cambridge University Rover Scouts, and last year's expedition was planned in the light of that experience. All the stations were

at least five miles walk from the base camp at Glenmore Lodge. Weather observation did not take up the whole time after the camps had been made secure against bad weather. Once the camps were established, the observers turned their attention to many other geographical jobs. The Cambridge geographers spent ten days in late June excavating the near-permanent snow patches to obtain cross-sections of the banding in the snow. Another team was able to study and map beautiful miniature sand spits by their camp at Loch Avon. More than a hundred people were involved in this survey, but the vast amount of information collected only covers a small part of one year. In future it is hoped to obtain more samples of the weather in the Cairngorms, probably extending the survey into other seasons. This work, of which a full report is to be published, should appeal particularly to schools.

A similar but even more interesting development, from the point of view of the young amateur scientist, is the growth of the Tarn Survey Project of the summer of 1947, when Brathay Hall was first opened as a holiday centre for boys from industry, into the Brathay Exploration Group in 1950. The idea originated when Brian Ware, while deputy warden of Brathay Hall, was told by Vaughan Lewis, of the Department of Geography of the University of Cambridge, of the absence of detailed information about the depths of the tarns in the Lake District, and the serious obstacle it constituted to research on glacial erosion in the District. The challenge of this relatively simple but real task of exploration led to the organization, in August 1947, of an expedition to Easedale Tarn, followed later by a second expedition to Angle Tarn under Bowfell, for which purpose a new collapsible and portable boat was devised. The success of these two expeditions encouraged the organization of a more ambitious expedition in the following year to Bleawater, and from that time the principle of recruiting boys equally from schools and industry became the basis for future developments, and the principle of using a mountain camp as base was established. It also proved the value of recruiting junior leaders for expeditions from among university undergraduates. Four other parties were organized in August and September 1949, and for the following year plans were laid on the assumption that Brathay Hall itself would again be the base for expeditions. It was also realized that if the Tarn Surveys were to take on a permanent and useful form, suitable separate headquarters would be needed, and the survey would require broadening to include a wide range of field-study. The 1950 surveys in the Lake District were handicapped by bad weather, but notwithstanding, successful surveys of three tarns were made, and an expedition to the Jotunheim Mountains in Norway was also organized, where the members undertook definite tasks in a programme of research organized by the Department of Geography at Cambridge. From a base-camp set up at Visdal, one party carried out a plane table survey of the glacial features of a corrie, under Glittertind, which had not previously been mapped in detail, and made observations and measurements to determine the nature of a large ice apron in the corrie. The second party carried out a detailed sounding of Juvatnet, a lake lying under the ice cliffs of the Kjedlan corrie glacier.

The following year marked the transition from the Tarn Surveys, run as part of the 'Holidays with Purpose' scheme, to the fully constituted and self-contained Exploration Group. The new headquarters could not be built during the year; but the programme of field-work included the detailed charting of five more tarns and some preliminary work on tarn temperature régimes, and in freshwater biology and botany. Previous experience had indicated that a party of eight boys and two leaders was the largest practical unit for field-work, and that by far the most successful parties were those in which schools and industry were equally represented, and in which individual schools and firms were represented by one or two boys rather than by three or four, and in which there was a nucleus of boys who had been members of at least one previous expedition. During this period, 1947–51, more than 250 boys participated in the expeditions and a panel of some thirty voluntary leaders was built up, while twenty tarns were charted for the first time.

The following year, 1952, the first in which the new headquarters in the Brathay Estate were available, four expeditions in the Lake District were organized, one surveying Codale Tarn and Hayswater; another to Angle Tarn above Patterdale; a third to Watendlath Tarn; and a fourth to Sty Head Tarn. There was also organized an expedition to the Jotunheim in Norway; but bad weather severely curtailed the major projects for a temperature survey of Juvatnet, and tunnelling through the firn of the Kjedlan corrie glacier.

In the summer of 1953 three of the four expeditions commenced an intensive survey of the Bleawater corrie, under High Street, including the temperature régime, a study of the geomorphology of the corrie, including the making of an accurate profile from the ridge of High Street, through the main and lower corries, to the Haweswater valley; a profile of the neighbouring Riggindale; and an examination of the widespread and varied evidence of glaciation, and a study of the meteorology of the corrie, including particularly an investigation into the wind circulation as well as a pioneer botanical survey. The fourth expedition was divided into two groups, one of which undertook a temperature survey of Easedale Tarn and the other a survey and sounding of Burnmoor Tarn, which does not lie in a corrie. In August 1953 a third expedition went to Norway to complete the work carried out on the previous year, including the completion of the tunnel and the exploration of the *randkluft* below its inner end; an examination of the well-developed stone rings lying around Juvasshytta; and a survey of plants, from the almost barren plateau at just over 6,000 ft. down to the tree line at about 4,000 ft. In the same month an expedition was arranged to Iceland which, although independent, maintained close liaison with an expedition from the University of Cambridge. From the base camp at the north end of Kaldidalur a weather station was set up at an altitude of 3,900 ft. A plane-table survey of a volcanic crater was made on a scale of 1/5,000, while another party surveyed by compass and 100-ft. tape an ice-margin lake—Thorisdalurvatn—on the east side of Thorisdalur. From the base camp a vertical soil section 11 ft. deep was dug in a stream bank, and a plane-table traverse with aneroid heights was made of the Geita from Kaldidalur to the Hvita Plain.

Under expert guidance, the amateur archæologist also frequently helps his professional colleague. In 1951, for example, a broadhead three-note bone whistle dated from the Iron Age was discovered by members of a Study Course in Field Archæology at

the Malham Tarn Field Study Centre in excavating a burial site between Gordale Beck and the road to Malham Tarn. (*To be continued*)

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MINERAL DRESSING AT THE ROYAL SCHOOL OF MINES, LONDON

WITHIN recent decades the increasing industrial demand for engineering metals and non-metallic minerals has led to the exploitation of mineral deposits too low in grade or too complex in ore structure to be profitably worked by the simpler methods in use thirty years ago. Though the demand still rises steadily, most of the older deposits are already in full production or even approaching exhaustion. Difficulties of climate, power, access and mechanized mining have been overcome to a gratifying extent; but the extraction of small quantities of valuable material from a large amount of associated host-rock still presents many difficulties.

In addition to modernized developments of the older methods of mineral dressing, in which gravity, ferromagnetism, electrical conductivity and the skill of the hydro-metallurgist are exercised, the process of froth-flotation has grown in importance. It provides the only method of concentration in many ore-dressing plants, and is used at some point in most of the others. The process is applied to finely ground ore pulped with water. Each ore particle must be so small that its settling velocity is of the Stokesian rather than the Newtonian order. There are two main reasons for this: first, the separation of value from waste depends on differences between the surface tensions of the particles undergoing treatment, and these differences cannot be exploited if the masses of the reacting particles introduce a high gravitational pull; secondly, the desired particles must be freed by grinding from those which are to be rejected, and this liberation is only effective when a substantial part of the ore has been ground well below 50 μ. Particles only a few microns in diameter are usually responsive to treatment.

Liberation by wet grinding is practised under close physical control. The prepared ore-pulp next receives small additions of chemicals which control flocculation, detergency and the surface characteristics of the various minerals in aqueous suspension. The *p*H must be held within defined limits during the whole of the treatment. A copious supply of air-bells is next blown through the pulp. As a result, particles which are relatively aerophilic are attracted into the interface between water and air and rise to the surface of the pulp where, with the help of a suitable frothing chemical, they form an unstable mineralized froth which is removed from the system. Huge tonnages of ore are treated daily along these lines.

In recognition of the vital importance to industry of a trained scientific outlook in developing and operating such processes as the one outlined above, the University of London instituted a degree course in mineral dressing in 1952. This is a B.Sc. option (engineering) in metallurgy, and it carries with it the associateship of the Royal School of Mines. On March 17 the new laboratories built in connexion with this degree course and its associated research

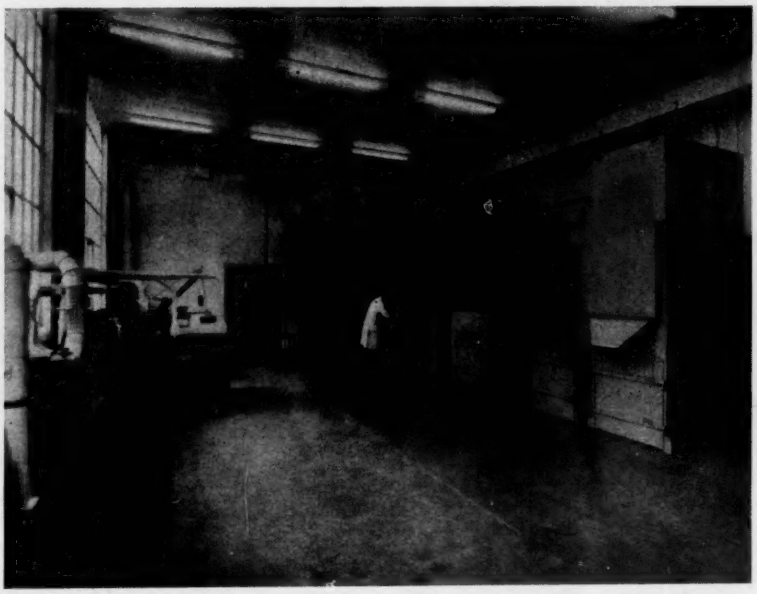

Fig. 1. Crushing room. Right, jaw crusher, Symons cone crusher, set of rolls, automatic sample splitter and a Sherwen screen; left, small crushing machines. Ore is moved by electric crane and mono-rail

Fig. 2. Small wet-grinding mill in closed circuit with an Atkins classifier

activities were 'at home' to visiting scientists, when a comprehensive range of dry-crushing, wet-grinding and sampling machines were demonstrated. All the machines are protected by a dust-control system which permits virtually all the rock treated to be recovered in the end-products. The crushing section is under negative pressure, so that the main testing laboratories are not contaminated by air-borne mineral dusts. In the research section, which is reached through air-locks, all air is spray-washed and filtered before entry, the block being kept under a slight positive pressure to ensure freedom from similar contamination. These precautions have been taken because in the atmosphere of South Kensington a freshly sheared mineral surface receives sufficient hydrocarbon coating from the air in a minute or less to make its surface reactions quite unreliable. Under the new air control, not only the materials being tested, but also the reagents and apparatus, remain chemically clean for reasonably long periods.

During the 'at home', some standard ore-dressing operations were demonstrated, either on a miniature scale or as pilot-sized operations such as are conducted in commercial plants. Exhibits were also arranged to show something of the research work now under way in the special laboratories. These included the use of supersonic waves to influence sorption-rate from the water phase through the zeta-zone to immersed mineral surfaces; pressure-leaching as a hydro-metallurgical method of direct extraction of metals in the form of soluble salts; sub-sieve sizing by sedimentation and elutriation; radiotracer equipment to be used with fatty acids in the study of sorption phenomena at mineral surfaces; identification of minute quantities of unknown minerals by a combination of selective separation and micro-chemistry; thin section radiography for micro-examination of minerals and mill products; a motor-driven stage and counting machine for quantitative assessment of particle types under the microscope; and a comparatively new method of testing the surface condition of small particles. Although the operations shown were limited by considerations of suitability for rapid demonstration as well as by the fact that the research work is only now settling down in its new home, it is clear that a wide field of scientific investigation has yet to be surveyed in terms of the special requirements of the mineral industry, and that measures have been taken to correlate this work with its commercial utilization. In this connexion, the traditional policy of making suitable provision for industrial ore-testing at the Royal School of Mines has been retained, so far as considerations of space and staffing permit.

One overriding justification for the new degree course and its allied activities is the shortage of suitably trained mineral-dressing engineers. This dearth has proved a restrictive factor in the development of the large low-grade deposits on which modern industry increasingly depends, and is felt in every part of the world. During the next few years the Mineral Dressing Section of the Royal School of Mines expects to meet part of this need by giving accelerated training to postgraduate students; but it is felt that the long-term answer involves a steady increase in the number of graduates specially trained in this subject. Since much of the work can be done in the mill laboratory under pleasant, interesting and clean conditions it is not proposed to restrict intake to men only, though all those entering must be prepared to spend the first few years of their working careers outside Great Britain.

E. J. Pryor

OBITUARIES

Lady Robinson

The death of Gertrude Maud Robinson, wife of Sir Robert Robinson, Waynflete professor of organic chemistry in the University of Oxford, came as a profound shock to chemists throughout the world, and in particular to those in many universities who have been privileged to know her. Her contributions to chemical knowledge have been substantial in spite of many pressing calls on her time and energy. With characteristic enthusiasm she was working in the laboratory a few days before her death, and it is in the dual role of an indefatigable research worker and a kindly hostess that she will long be remembered. In particular, the younger members of the teaching staffs and their wives have reason to be profoundly grateful to her; she found time to take a personal interest in them and their families, which lasted long after they moved elsewhere. One other aspect of her

devoted life must also be mentioned. To her must be due in no small measure the unique position which Sir Robert holds to-day among the chemists of the world.

On January 21 of this year, Lady Robinson's contributions, direct and indirect, to organic chemistry were recognized by the award of the honorary degree of Master of Arts of the University of Oxford, a gesture which warmed the hearts of chemists everywhere.

Lady Robinson's scientific papers, mainly in the *Journal of the Chemical Society*, record work carried out in the Universities of Manchester, Sydney, Liverpool, St. Andrews, London (University College), and the Dyson Perrins Laboratory, Oxford. The first two, with Dr. C. Weizmann, were published in 1910 and 1911 under her maiden name of Walsh. Many of the later papers were published jointly with Sir Robert Robinson. In work on certain derivatives of catechol ethers, the important discovery was made that asymmetrical substitution occurred in azoxy compounds, thus adding proof to that earlier provided by Angeli of the asymmetrical structure of the azoxy compounds themselves. Another series of papers of considerable novelty dealt with nitrogenous pseudo-bases, and the mechanism of Fischer's indole synthesis. Still another series described the development of new methods for the synthesis of high-molecular weight fatty acids, notable among which was a variation of the acetoacetic ester synthesis for the extension of the carbon chain by twelve carbon atoms at a time; this elegant process culminated in the synthesis of *n*-triacontanoic in 1934.

Lady Robinson published numerous papers on the anthocyanins and their separation by distribution between two partially miscible solvents, a method which was virtually a forerunner of modern partition chromatography. More recently still, her interest in these compounds led her to undertake a very difficult task, namely, the investigation of the leucoanthocyanins, in particular peltogynol. She took an active part in the work on penicillin during the Second World War, and it is perhaps not generally known that she was the first chemist to prepare synthetical material with genuine antibiotic character of the penicillin type.

Lady Robinson's name is assured of a lasting and honoured place among those organic chemists who have made major contributions to their science.

W. Baker

Prof. E. Esclangon

We regret to record the death on January 28 of M. Ernest Esclangon, the *doyen* of French astronomers, at the age of seventy-seven.

Esclangon started astronomical work at Bordeaux in 1899, taking a regular share in the routine work of the Observatory, observing minor planets and comets and making observations with the meridian circle and equatorial. But although he remained throughout his life associated with observatories, his principal achievements were not in astronomy, apart from administrative work. While still at Bordeaux he carried out gravity determinations in south-west France, relative to the standard at Paris. After the outbreak of war in 1914, he assisted in the geographic service of the French Army, doing work on sound-ranging and making a study of the sound waves resulting from the firing of a gun and the passage of a shell through the air. Towards the end of the First World War he took part in researches concerning submarines.

In 1919 Esclangon was appointed director of the Observatory at Strasbourg, which had been taken over from the Germans. Here he had the opportunity of publishing the work he had done during the War and of extending his researches to such subjects as the zones of silence at various distances from explosions, the rotation of projectiles around their centre of gravity, and the tides. He was so successful in building up an effective observatory at Strasbourg that when Deslandres retired from the directorship of the Observatories of Paris and Meudon in 1929, he was appointed to this important post.

Esclangon was always interested in the time service in which Paris has for long played an important part. He developed methods for the synchronization of pendulums electrically, and he introduced the speaking clock which latterly gave accurate time signals to 16 million Parisians annually. After acting as host for the general assembly of the International Astronomical Union at Paris in 1935, he was elected president of that Union for the next three years, terminating with the congress at Stockholm in 1938. He was president of the Paris Academy of Sciences in 1942, and finally retired in 1946. His services to astronomy were recognized in Great Britain by his election as an Associate of the Royal Astronomical Society in 1932.

J. Jackson

NEW FELLOWS OF THE ROYAL SOCIETY

At the meeting of the Royal Society on March 18, the following were elected to fellowship:

Prof. D. H. R. Barton, professor of organic chemistry, Birkbeck College, London, distinguished for his fundamental contributions to the chemistry and stereochemistry of terpenes, triterpenes and steroids.

Prof. T. MacF. Cherry, professor of mathematics, University of Melbourne, distinguished for his researches on transonic flow and for earlier work on orbits in celestial mechanics.

Prof. E. G. Cox, professor of inorganic and physical chemistry, University of Leeds, distinguished for his contributions to stereochemical problems in inorganic and organic chemistry by the application of X-ray crystallographic methods.

Dr. F. C. Frank, reader in physics, University of Bristol, distinguished for his original contributions to theories of crystal growth, of plastic deformation and of dislocations in crystalline solids.

Prof. A. B. Hill, professor of medical statistics, University of London, distinguished for his work on the application of statistical methods to medical problems, including the evaluation of new therapeutic and prophylactic drugs.

Prof. E. S. Hills, professor of geology and mineralogy, University of Melbourne, distinguished for contributions to palæontology, particularly of Devonian and Tertiary faunas, and for geological studies in Australia.

Sir Christopher Hinton, managing director, Industrial Group, Department of Atomic Energy,

distinguished as an engineer who, by his leadership and by direct contributions, has played a major part in the development of large production plants in the British Atomic Energy Project.

Prof. F. E. King, professor of chemistry, University of Nottingham, distinguished for his original contributions to synthetical organic chemistry, and for his investigations on wood extractives.

Dr. H. G. Kuhn, lecturer in physics, University of Oxford, distinguished for his development of delicate interferometric techniques, his work ranging from the study of continuous spectra to the examination of hyperfine structure.

Dr. H. W. Lissmann, assistant director of research, Department of Zoology, University of Cambridge, distinguished for his researches on animal behaviour, including the demonstration of a new form of sensory activity in animals.

Prof. F. C. MacIntosh, professor of physiology, McGill University, Montreal, distinguished for his researches in the physiology and pharmacology of the central and peripheral nervous system, and for methods of biological assay.

Dr. L. Harrison Matthews, director, Zoological Society of London, distinguished for his work on the physiology of reproduction.

J. L. Pawsey, assistant-chief, Radiophysics Division, Commonwealth Scientific and Industrial Research Organization, Sydney, distinguished for his contributions to techniques of radio and radar, and in particular for his applications of these techniques to radio astronomy and to the study of the ionosphere.

Dr. M. F. Perutz, lecturer in biophysics, University of Cambridge, distinguished for his elucidation of the structure of complex protein molecules by X-ray diffraction methods; for his detailed study of the structure and properties of hæmoglobin; and for his investigations of the structure, deformation and flow of glacier ice.

Prof. A. J. S. Pippard, professor of civil engineering, Imperial College of Science and Technology, London, distinguished for his theoretical and experimental contributions to the theory of structures.

Dr. Rosalind V. Pitt-Rivers, biochemist, National Institute for Medical Research, London, responsible for notable advances in the biochemistry of the thyroid gland.

Prof. R. D. Preston, professor of plant biophysics, University of Leeds, distinguished for his investigation of the fine structure of plant cell walls.

Dr. J. W. S. Pringle, lecturer in zoology, University of Cambridge, distinguished for his researches on neuromuscular co-ordination and the mechanism of equilibration in insects.

F. J. Richards, senior principal scientific officer, Research Institute in Plant Physiology, Imperial College of Science and Technology, London, distinguished for his researches on the effects of mineral deficiencies and for his work on developmental morphology in plants.

Prof. C. Rimington, professor of chemical pathology, University College Hospital Medical School, London, distinguished for his work on the biosynthesis of porphyrins.

Prof. W. W. Rogosinski, professor of pure mathematics, University of Durham, distinguished for his contributions to mathematical analysis, particularly in the theory of functions and the theory of series, especially Fourier series.

Dr. F. Sanger, biochemist, Medical Research Council, Cambridge, distinguished for his studies on protein structure, especially that of insulin.

Prof. H. G. Thode, head of the Chemistry Department, McMaster University, Hamilton, Ontario, distinguished for improvements in the technique of mass spectrometry and for the application of mass-spectrometric methods to problems in nuclear physics, chemistry and geochemistry.

Dr. W. A. Waters, lecturer in organic chemistry, University of Oxford, distinguished for his researches into the mechanism of organic reactions, especially those involving free radicals.

Dr. C. B. Williams, head of the Department of Entomology, Rothamsted Experimental Station, distinguished for his pioneer work on migration of Lepidoptera and his studies of insect populations.

NEWS and VIEWS

Physics at Cardiff : Prof. R. T. Dunbar

Prof. R. T. Dunbar, who retires this summer from the chair of physics in University College, Cardiff, has been associated with the Physics Department at Cardiff for the past thirty years. Following a period of teaching and research at Edinburgh with the late Prof. C. G. Barkla, he was in 1924 appointed lecturer and director of the Viriamu Jones Research Laboratory, Cardiff, and held this position under both Prof. A. L. Selby and Prof. H. R. Robinson. It was during this period that he was able finally to dispose of Barkla's proposed *J* phenomenon. The planning and equipping of the new Tatem Laboratories in Cathays Park, Cardiff, which were then begun, were entrusted to him. Since 1930, when he succeeded to the chair, Prof. Dunbar has devoted himself to the needs of his students and to the increasing demands of a growing Department. During the years of economic depression between two World Wars and again during the Second World War, the capacity of the new laboratories was fully taxed, so that the accommodation has recently had to be extended once more. The present facilities and equipment of his own Department testify to his vision and energies, but the rest of the College, too, has benefited much from his personal and detailed interest in all aspects of its growth.

Prof. A. J. C. Wilson

Prof. A. J. C. Wilson, who succeeds Prof. Dunbar, has had a distinguished record as an X-ray crystallographer. From Dalhousie University, Nova Scotia, and the Massachusetts Institute of Technology, he went in 1938 to the Cavendish Laboratory, Cambridge, as an 1851 Exhibitioner, and quickly showed an exceptional ability in both experimental and theoretical work. He carried out some beautiful work on the measurement of coefficients of expansion of

metals by X-ray diffraction, but it was apparent that his theoretical ability was his greater gift, and he made several important fundamental contributions to the theory of the diffraction of X-rays by crystals; his work on diffraction by imperfect crystals is likely to remain standard for a long time. He was quick to realize the importance of apparently trivial observations, and a chance remark by one of his colleagues at Cambridge set him thinking along a new line—the distribution of intensity in the different orders of diffraction from a single crystal. Unable to proceed far with this subject during the war years, he took it up seriously upon his appointment as senior lecturer at Cardiff, and, with several of his colleagues, he published a series of papers which have revolutionized ideas about the determination of space groups. The methods described have already proved extremely useful in many crystal-structure determinations. Prof. Wilson has also shown himself to be an extremely able administrator, his work on editing "Structure Reports" and producing data for the "A.S.T.M. Index" alone putting the world of X-ray diffractionists greatly in his debt.

Pharmacology and Therapeutics at Sheffield: Dr. G. M. Wilson

Prof. E. J. Wayne is resigning at the end of this month from his post as professor of pharmacology and therapeutics in the University of Sheffield, in order to take up the chair in the practice of medicine in the University of Glasgow, and will be succeeded by Dr. G. M. Wilson, at present lecturer in therapeutics in the University of Sheffield. Dr. Wilson was educated at the Edinburgh Academy and the University of Edinburgh, qualifying as a medical practitioner in 1940. During 1941–46 he served in the Medical Branch of the Royal Air Force, becoming officer in charge of the Medical Division of No. 5 R.A.F. General Hospital, Cairo, and medical specialist to the R.A.F. Middle East Command Medical Board. After demobilization, he was appointed an assistant to the Medical Unit of St. Mary's Hospital, London. He went to the University of Sheffield in 1950 as lecturer in therapeutics and a year later was appointed senior lecturer in therapeutics and a consultant physician to the United Sheffield Hospitals. He spent the academic year 1952–53 at Harvard University on an Eli Lilly travelling fellowship in medicine of the Medical Research Council. Since the War, Dr. Wilson has carried out a series of studies of some disorders of the peripheral circulation, and he has recently been studying the part played by the endocrine system in the development of metabolic and cardiovascular disturbances.

Statistics in the University of Aberdeen

The University of Aberdeen is creating the new post of reader in statistics as from October 1, 1954. Dr. D. J. Finney, lecturer in the design and analysis of scientific experiments in the University of Oxford, will be the first holder of this readership. Dr. Finney will be in charge of teaching and research in this Department of Statistics, in which new developments, including the provision of increased statistical services for other University departments, are under consideration. The Agricultural Research Council is simultaneously establishing a new Unit, the Unit of Statistics, within the University of Aberdeen. Dr. Finney will be the director of this Unit, and in this capacity will collaborate with Agricultural Research Council institutes in Scotland and assist in the design and analysis of their experiments. Dr. Finney's advice will also be available to other institutes and organizations concerned with agricultural research in Scotland. In addition, the Unit of Statistics will be responsible for carrying out specific investigations on behalf of the Council. The University Department of Statistics and the Agricultural Research Council's Unit will be housed in Marischal College, Aberdeen.

Royal Geographical Society: Awards for 1954

H.M. The Queen has approved the award by the Royal Geographical Society of the following Royal Medals: *Founder's Medal*, to Brigadier Sir John Hunt, leader of the British Mount Everest Expedition; *Patron's Medal*, to Dr. N. A. Mackintosh, deputy director of the National Institute of Oceanography, for research and exploration in the Southern Ocean since 1924, with special reference to his voyages in the *Discovery II* during 1929–31 and 1933–35. The Council has made the following awards: *Murchison Grant*, to G. R. Crone, librarian and map curator of the Royal Geographical Society, for contributions to the history of cartography and to the history of geography; *Back Grant*, to Commander G. S. Ritchie, of the Hydrographic Department of the Admiralty, for his contribution to oceanographical exploration as commanding officer of H.M.S. *Challenger* during 1950–51; *Cuthbert Peek Grant*, to Dr. T. E. Armstrong, of the Scott Polar Research Institute, University of Cambridge, for studies in the history and economic development of the Arctic, with special reference to the northern sea route; *Gill Memorial*, to Dr. W. G. V. Balchin, lecturer in geography, King's College, London, for contributions to geomorphological and geographical research; and *Mrs. Patrick Ness Award*, to C. W. M. Swithinbank, Pembroke College, Oxford, formerly a member of the Norwegian–British–Swedish Antarctic Expedition, 1949–52, for research in antarctic glaciology.

British Welding Journal

With the co-operation of the Institute of Welding and of the British Welding Research Association, a new monthly periodical, the *British Welding Journal*, has been started, and the first part has just been published (2 Buckingham Palace Gardens, London, S.W.1. Members, free; non-members, 10*s*.). As Dr. J. H. Paterson, a past president of the Institute of Welding, remarks, "when it is considered that the first practical applications of the welding of metals on any considerable scale are not much more than sixty years old, it is remarkable how rapidly this process has attained its present proportions". All aspects of the subject are undergoing intensive scientific and technical investigation, and it is to provide a unified avenue of publication for such work that the new *Journal* is primarily intended. This combination of the proceedings of the Institute of Welding, in the main practical in character, and the scientific reports of the Welding Research Association, together with reviews of current literature, should, in the words of Sir William Larke, "make available to the technologist the results of research, so that they can be translated into practice; and bring to the knowledge of the research worker the difficulties which arise in their practical application". Among the papers contained in this first issue are the following: a most interesting historical account dealing with the development of

metal-arc welding and electrodes during the past half-century; welding as a career; the welded structure in a pump-house foundation; the effect of steel quality on spot-welding properties; and the use of self-adjusting arc equipment for welding a light-alloy deckhouse. The presentation of the *Journal* is excellent, permitting photomicrographs to be reproduced with admirable clarity. It should perform a most valuable function in a sphere of metallurgy and engineering which is bringing about a revolutionary change in the constructional field.

A Systemic Rust Fungus

When the uredospores of the autoecious rust *Puccinia suaveoleus* attack the creeping thistle *Cirsium arvense*, isolated uredo-pustules, usually with some teleutospores, are formed (B. P. Menzies, *Ann. Bot.*, N.S., **17**, 68 and 551; 1953). The mycelium later grows down into the roots and becomes systemic. In some of the root-buds the mycelium appears unchanged and bears uredosori; in others it undergoes a somatic segregation of mating type and bears spermogonia only. Teleutospore germination is so erratic that basidiospore infection is responsible for only a small amount of the spermogonial infection observed. The spermogonial mycelium in the systemically infected shoots is heterothallic, and there are two mating types. All the spermogonia on one shoot bear spermatia of only one mating type. Therefore, segregation of mating type must take place at the base of the shoot or even in the roots. The multinucleate condition of the mycelium in both uredosoral and spermogonial shoots makes it impossible to observe segregation directly.

Common Marine Bivalves of California

A guide to some sixty species of Californian lamellibranch molluscs of economic importance has been compiled by John E. Fitch and published under the title "Common Marine Bivalves of California" (Fish Bulletin No. 90 of the Department of Fish and Game, State of California; pp. 102; San Francisco, 1953). The first twenty pages contain general information on nomenclature, habits, structure and reproduction of marine bivalves, and also give methods of collecting, culturing and preparing edible species. Then follows a key for identification of the species, with diagrams to illustrate technical terms. The main section comprises descriptions of the species, a page being allotted to each. A photograph of the outside of the shell is given; but only in the piddocks and gapers are the siphons shown. A brief description of distinguishing characters is accompanied by notes on the range of each species in California, its habits and economic use. A number of species of no economic value, but which may be taken when searching for food or bait, are included. The author has made an attempt to standardize the names by which the commoner bivalves are known, and has found it necessary to change some to accord with their phylogenetic relationships. The style of this pamphlet is clear and concise, and the black-and-white photographs are excellent. Although intended for the amateur naturalist or clam digger, this work has considerable scientific value. The method of presentation might well form a basis for other publications of a similar nature.

University of Leeds: Gifts to Departments

Gifts made to various departments in the University of Leeds include the following: to the Department of Physical Chemistry, £700 from the Anglo-Iranian Oil Co., Ltd., for research, and 5,000 dollars from the Rockefeller Foundation for research in radiation chemistry under the direction of Prof. F. S. Dainton; to the Department of Textile Industries, £250 from the Anglo-Iranian Oil Co., Ltd., for research; to the Department of Civil Engineering, £500 from the Cement and Concrete Association for scholarships and £200 a year (plus income tax) for seven years from Wm. Airey and Son (Leeds), Ltd., for scholarships in concrete technology; and to the Department of Colour Chemistry and Dyeing, £5,000 from the British Silk Dyeing Co., Ltd., Balloch, Alexandria, Scotland, for research.

Department of Scientific and Industrial Research: Grants to Research Workers and Students

The Department of Scientific and Industrial Research is offering three types of grants to British research workers and students normally resident in Great Britain: maintenance allowances (approved fees plus £245–325) to postgraduate students for a year's full-time training in the methods of scientific research; senior research awards (maximum of £600 a year) for postgraduate research; and grants for special researches to enable investigators to obtain scientific, laboratory or clerical assistance or to purchase special equipment, materials or services not normally provided by a university for scientific purposes. Generally speaking, candidates for maintenance allowances or senior research awards should not be more than twenty-seven years of age. All the awards are tenable in universities, colleges, establishments of the Department of Scientific and Industrial Research, research association laboratories and other institutions approved by the Advisory Council for Scientific and Industrial Research. The closing date for applications for maintenance allowances is April 15 and for the other awards April 1. Further information is available in a pamphlet, "Notes on D.S.I.R. Grants to Research Workers and Students" (price 6*d.*), obtainable from the Department at Charles House, 5–11 Regent Street, London, S.W.1.

Colonial Service: Recent Appointments

The following appointments have recently been made in the Colonial Service: J. R. Antoine (assistant plant pathologist, Mauritius), senior agricultural officer, Mauritius; P. C. Chambers (director of agriculture, Cyprus), director of agriculture, Northern Region, Nigeria; M. Robson (conservator of forests, Nigeria), chief conservator of forests, Western Region, Nigeria; I. Langdale-Brown, botanist, Uganda; J. P. T. Boorman, scientific officer (entomologist), Nigeria; D. N. F. Hall and J. H. Wickstead, scientific officers (fisheries), Singapore; F. H. Talbot, scientific officer, East Africa High Commission; P. J. Larkin, veterinary officer, Kenya; P. A. L. Wight, veterinary officer, Nyasaland; E. F. W. O. Brunig, assistant conservator of forests, Sarawak; N. W. Neal, veterinary officer, Uganda; J. Nicholls, livestock officer, Nyasaland; F. S. Peritz, veterinary officer, Local Civil Service, Gold Coast; J. F. Redhead, assistant conservator of forests, Nigeria; J. M. A. Sly, scientific officer (agronomist), Nigeria; S. R. Smithers, scientific officer, Gambia; H. A. W. Southon, scientific officer (entomologist), East Africa Tsetse and Trypanosomiasis Research and Reclamation Organization, East Africa High Commission; L. G. Stephens, veterinary officer, Hong Kong;

S. L. Wanrooy, tobacco-growing expert, British Honduras.

The Night Sky in April

New moon occurs on April 3d. 12h. 25m., U.T., and full moon on April 18d. 05h. 48m. The following conjunctions with the moon take place: April 1d. 18h., Mercury 7° S.; April 4d. 18h., Venus 6° S.; April 8d. 03h., Jupiter 3° S.; April 19d. 05h., Saturn 8° N.; April 23d. 17h., Mars 1° N. Mercury is too close to the sun for favourable observation during the month. Venus, an evening star, rises at 19h. 50m., 20h. 35m. and 21h. 20m. on April 1, 15 and 30, respectively, the stellar magnitude of the planet varying between 3·4 and 3·3 and the visible portion of the illuminated disk between 0·967 and 0·929. Mars rises at 1h. 15m., 0h. 50m. and 0h. 10m. at the beginning, middle and end of the month, respectively; its eastward movement during April carries it a little north of λ Sagittarii towards the end of the month, and its stellar magnitude varies from 0·1 to − 0·6, the great increase in brightness being largely due to its approach to the earth, from 89 to 66 million miles during April. Jupiter sets at 0h. 50m., 0h. and 23h. 15m. on April 1, 15 and 30, respectively, its stellar magnitude varying from − 1·7 to − 1·6; its slow eastward movement from the west to the east of ζ Tauri can be easily seen during the month. Saturn rises at 20h. 50m., 19h. 50m. and 18h. 40m. on April 1, 15 and 30, respectively, and is easily recognized, stellar magnitude 0·4, a little east of κ Virginis. Occultations of stars brighter than magnitude 6 are as follows, observations being assumed to be made at Greenwich: April 6d. 20h. 44·7 m., 36 Taur. (*D*); April 8d. 21h. 31·9 m., 5 Gemi. (*D*). *D* refers to disappearance. The Lyrid meteors, the debris of Comet 1861 I, are active during about April 20–22, but moonlight will interfere with their observation during the later part of the night.

Announcements

The Council of the Linnean Society of London has nominated Prof. F. E. Fritsch, emeritus professor of botany in the University of London, for the award of the Linnean Gold Medal for 1954, and Prof. Irene Manton, professor of botany in the University of Leeds, for the Trail Award and Medal. The presentation will be made at the Anniversary Meeting on May 24.

The Hinchley Medal of the British Association of Chemists has been awarded to Mr. George T. Gurr, an authority on stains for microscopical work and their manufacture and author of "Biological Staining Methods", who has been prominently connected with the Association for a number of years.

Dr. A. R. J. P. Ubbelohde, professor of chemistry in The Queen's University of Belfast, has been appointed to the University of London chair of thermodynamics tenable at the Imperial College of Science and Technology.

Dr. B. P. Dudding, vice-chairman of the Advisory Scientific Panel of the Research Laboratories of the General Electric Co., Ltd., has been made an "Ufficiale dell' Ordine al Merito della Repubblica Italiana", in recognition of his services to the Italian glass industry. Dr. Dudding has given long service to various bodies connected with glass and glass technology, both national and international, and was president of the International Commission on Glass in July last year.

A Faraday Society Discussion on "The Study of Fast Reactions" will be held during April 7–9 in the Department of Chemistry, University of Birmingham, under the chairmanship of the president of the Society, Prof. R. G. W. Norrish. The meeting will be in two parts, gas reactions and solution reactions, which will be given a general introduction by Prof. H. W. Melville (University of Birmingham) and Mr. R. P. Bell (University of Oxford), respectively. Further information can be obtained from the Secretary of the Society at 6 Gray's Inn Square, Gray's Inn, London, W.C.1.

The Imperial College of Science and Technology will be holding a summer school in mineral dressing in the Bessemer Laboratory, Royal School of Mines, Prince Consort Road, London, S.W.7 (see p. 565 of this issue), during September 14–17 (10 a.m.–5 p.m. each day). The course will include lectures covering comminution, classification, grinding control, gravity separation, flotation and ancillary processes and will be illustrated by films, demonstrations and class work. The fee for the course is £10 10*s*. Application forms can be obtained from the Registrar, Imperial College, Prince Consort Road, London, S.W.7.

The conference on oxidation processes, arranged jointly by the Institution of Chemical Engineers, the Chemical Engineering Group of the Society of Chemical Industry, the Royal Institution of Engineers (Chemical Engineering Group) of the Netherlands and the Royal Netherlands Chemical Society (Section for Chemical Technology) (see *Nature*, February 6, p. 245), will not now be held in The Hague, as previously announced, but instead will be in Amsterdam during May 6–8 at the Royal Tropical Institute (Koninklijk Instituut voor de Tropen), Mauritskade 63.

The Third General Assembly and International Congress of the International Union of Crystallography will be held in the Faculté des Sciences, 47 rue des Écoles, Paris 5*e*, during July 21–28. Two symposia are being arranged to take place during the Congress: location and function of hydrogen, organized by Dr. W. Cochran, of the Cavendish Laboratory, Cambridge; and the mechanism of phase transitions in crystals, organized by Dr. W. G. Burgers, of the Technical Institute, 136 Julianalaan, Delft. Those intending to participate in either of these symposia should write before March 31 to the organizer and also to the secretary of the Congress, A. J. Rose, 1 rue Victor-Cousin, Paris 5*e*, from whom all further information concerning the Congress can be obtained.

It is proposed to publish in the near future a new journal, to be entitled *Gwerin: an International Journal of Folk Life*, which will be devoted to papers, notes, reviews, etc., on all aspects of folk-life research in Great Britain and Ireland and their relations with the Continent of Europe (including Scandinavia). The language of the journal will be English. The general editor of the journal is Dr. Iorwerth C. Peate, curator of the Welsh Folk Museum, St. Fagans, near Cardiff. Two parts will be published each year, each being about sixty pages (7¼ × 9¾ in.), with plates, and costing 5*s*. 6*d*. post paid. All those wishing to subscribe to this new journal should write as soon as possible to Dr. Peate.

A NEW GYROSCOPIC INSTRUMENT

A NEW instrument known as the 'Gyrotron', which has been made by the Sperry Gyroscope Co.[1], is an important step in aircraft instrumentation and is interesting in that it has been developed from observation of the flight-control methods of Diptera. J. W. S. Pringle was the first to give a fully satisfactory explanation of the mechanism and functions of the halteres of Diptera[2]. These club-shaped lateral projections from the fly's thorax vibrate in a vertical plane through an angle of some 150° during horizontal flight, the motion having a constant amplitude and being maintained at the natural frequency of the system (Fig. 1). The large amplitude of this motion means that in the plan view the mass represented by the end knob of the haltere has a lateral in-and-out motion at twice the frequency of the oscillation of the haltere, since the knob moves inwards and outwards for the half-cycle while it is above the horizontal position, and again for the half-cycle while it is below this position. By reason of this in-and-out component of the motion, the fly is able to detect a yawing turn. If during flight the fly starts such a turn (about the vertical axis), forces, called Coriolis forces, are developed as a result of the combination of the turn with the motion described. These Coriolis forces also arise in gyroscopic apparatus and, as will be seen later, in the new type of 'vibratory gyro'.

The Diptera have sense organs at the base of the halteres which detect the action resulting from the Coriolis forces. These give a signal which enables the fly to correct the rotation and maintain a straight course—a task which experiment shows to be impossible for a fly from which the halteres have been removed.

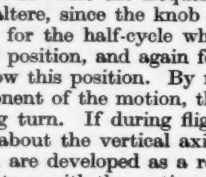

Fig. 1. Diagram illustrating movement of halteres

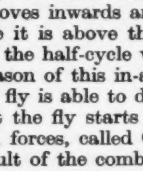

Fig. 2. Plan of vibrating tuning fork

The engineers developing the 'Gyrotron' had to produce an instrument sensitive to a very much slower rate of yawing rotation than the fly's halteres, and their success is indicated by the fact that they are able to measure rotations as slow as that of the earth. This is done by a rugged instrument which has a range of speed indication up to about a hundred revolutions per minute.

The basic detector unit of the 'Gyrotron' consists essentially of a tuning fork which is maintained in vibration, with constant amplitude, by an electromagnetic drive. This is used to detect a rotation about the axis of the 'handle' of the fork (Fig. 2). The tines oscillate inwards and outwards in a way that corresponds to the essential part of the motion of the halteres of a fly. This leaves the problem of detecting the Coriolis forces generated when the fork is rotated about its axis.

Another way of expressing the Coriolis effect is to say that, as the tines oscillate, the moment of inertia of the fork about the handle axis varies periodically with the frequency of the vibration of the fork, and may be expressed by $I = I_0 + I_1 \sin \omega t$, where $n = \omega/2\pi$ is the frequency, I_0 is the moment of inertia of the fork when the tines are in the mean position, and I_1 represents the greatest departure from this mean. If a rotation, with constant angular velocity Ω about the handle axis, is given to the fork, the angular momentum about the axis is given by

$$V = \Omega\,(I_0 + I_1 \sin \omega t).$$

In order to maintain this rotation, the couple applied to the handle of the fork must be

$$L = \mathrm{d}V/\mathrm{d}t = I_1\,\Omega\omega \cos \omega t.$$

It is this alternating couple that the instrument engineer must detect and measure. It corresponds exactly to the requirements of the sense organs at the roots of the halteres, except that the sense organs observe each haltere independently, while in the 'Gyrotron' the tines of the fork always move in unison so that the effect on the fork as a whole may be observed.

The basis of detection is to support the fork on a torsional spring of such stiffness that its natural frequency on the spring is also n. The fork then develops an oscillatory torsional motion just as though the couple L were being applied to it directly, thereby making use of the large dynamic magnification of the resonant system. What is actually measured, by a suitable pick-up, is the velocity associated with the oscillatory rotation, which is superimposed on the steady applied rotation Ω. Provision is made for electromagnetic damping of the motion, this being necessary when measuring higher angular velocities. The velocity of the oscillatory rotation gives a measure of the angular velocity Ω, and its phase, relative to the tine motion, indicates the direction of Ω. The output signals are suitably combined to give a direct reading of angular velocity on a dial. A considerable amount of electronic equipment is, of course, used; but the whole instrument, including amplifiers, although only in the early stages of development, weighs less than 7 lb.

The development of this device as a normal rate-of-turn meter for aircraft is clearly an immediate possibility. It is at once more robust and more sensitive than the gyroscopic type currently in use. Future developments lead towards a directionally stable instrument (like a free gyroscope) and perhaps to a complete replacement of gyroscopic instruments—even the gyro-compass—by 'Gyrotron' types; for once it is possible to detect rotation in this way, it should ultimately be possible to maintain it at any desired value.

A. L. Percival

[1] Lyman, J., *Aeronaut. Eng. Rev.*, **12**, No. 11 (1953).
[2] Pringle, J. W. S., *Phil. Trans. Roy. Soc.*, B, **233**, 347 (1948).

POWER FROM ATOMIC ENERGY*

ONLY when concentrated sources of energy—or fuels—were discovered did modern civilization become possible. While complete mechanical use of their energy is possible in principle, this has not yet been accomplished even with chemical fuels, and only 30–40 per cent utilization of the irreversible heats of reaction is possible. Nuclear fuels, a million times more concentrated than chemical fuels, are now becoming practically useful, and thermonuclear reactions—at present used only explosively—may enter the field eventually.

Nuclear reactors cannot be very small and are probably impracticable for vehicles and aircraft—though very promising for ships. Their greatest importance—now that breeding is possible in fast reactors—will be as sources of large-scale power. The cost cannot be predicted realistically, but it might eventually come down to that of power from coal—which, in any event, represents only a few per cent of the cost of industrial products.

The practical difficulties of nuclear power production are immense. Materials have to withstand radiation and high temperatures. Operation of plant must be largely by remote control, and the large-scale disposal of fission products will be difficult. Very careful planning is necessary for safety and economy—because plants are necessarily large. The designers of the prototype submarine reactor—though 'firmly optimistic' about the future—have emphasized these problems, which will become still more acute in power breeders.

Countries have greatly differing needs for nuclear-power projects. The United States will clearly continue development—for prestige reasons and because it can now afford to export plant. Canada must be interested because of her undeveloped northern regions. The U.S.S.R., which can probably benefit more than the United States, will also be influenced by considerations of prestige. Many small European countries have entered the field—at the risk of absorbing too much of their technology. Africa and other undeveloped countries need nuclear power vitally.

In Great Britain nuclear power could augment coal power substantially and its prospects must be carefully examined. Allowing for, say, three generations of reactors during development and assuming an expenditure comparable to the present expenditure on new electrical generating plant, it would be approaching the end of the century before the present production of electricity from coal could be equalled. But by this date Britain ought to have increased power production about five times to compete industrially with the United States. Since only one-sixth of her coal is used to produce electricity in Britain, there is clearly no prospect of substantially reducing the consumption of coal, and a much greater effort should be devoted to fuel-saving.

At the same time, Britain has a unique opportunity of regaining her economic balance by exporting nuclear power plant to other countries. Such a project would require full industrial participation and a real national effort to increase scientific manpower and use of science, and to reduce waste. Among British assets are brain-power and freedom from the crippling 'spy-hunt' atmosphere, and atomic energy could have a decisive influence on Britain's future. But those who think this will come without effort are mistaken.

* Summary of a lecture by Prof. F. E. Simon, C.B.E., F.R.S., being the third of the series of public lectures arranged by the Atomic Scientists' Association and the Department of Extra-Mural Studies of the University of London (see also *Nature* of February 27, p. 386, and March 13, p. 477).

GROUND-WAVE PROPAGATION AT ULTRA-HIGH FREQUENCIES

THE general trend of development of television and other radio services to increasingly higher frequencies emphasizes the need for more detailed knowledge of the characteristics of wave propagation over the ground at such frequencies. Two papers of interest in this connexion were read before the Radio Section of the Institution of Electrical Engineers on February 10.

The first paper, by Dr. J. A. Saxton and B. N. Harden, described the results of an experimental investigation of the effects of irregular terrain on ground-wave propagation at frequencies of 102·6 and 593·6 Mc./s. Particular attention was paid to the work at the higher frequency, which is midway between the bands, known as IV (470–585 Mc./s.) and V (610–960 Mc./s.), allocated for the future development of television in Great Britain.

With the aid of an experimental transmitter set up first at the Radio Research Station, Slough, on a mast 28 m. high and 40 m. above sea-level, and later at the B.B.C. station at Sutton Coldfield, from a mast at a height of 184 m. above ground and 365 m. above sea-level, measurements of received field strength were made in various directions out to distances of nearly 100 km. Within this range, variations of field strength arising from changes in atmospheric refraction sometimes occur, but they are of little significance compared with the effects of the terrain, which result in relatively large changes in strength for different directions of transmission or for small displacements in the actual location of the receiver. Having in mind the irregular nature of the ground over which the propagation must be studied, the results of the variation of field strength with distance must be presented on a statistical basis. Thus it was found that at the lower of the two frequencies used (near to 100 Mc./s.) the relation between median field strength and distance agreed fairly closely with the theoretical values calculated for transmission over a smooth earth. At the higher frequency (near 600 Mc./s.), however, it was found that the median field strength at a distance of 70–80 km. may be as much as 20 db. below that estimated for smooth-earth conditions. Moreover, it was found that, with a receiving aerial at the usual height of about 9 m., considerable further attenuation may be experienced in heavily built-up areas. A fairly wide range of variation of field strength may also occur over a small range at any particular receiving site, in extreme cases amounting to 20–25 db. This experience indicates that considerable care may be needed in the choice of position of a receiving aerial when television transmission takes place at wave-lengths corresponding to one or two feet.

In the second paper, Dr. J. A. Saxton has collected information of the type described above, together with the results of similar investigations conducted in the United States, so as to compare the experi-

mental data for ground-wave propagation at frequencies between 50 and 800 Mc./s. with the corresponding conditions for transmission over a smooth earth. The graphs accompanying the paper show that, whereas for given transmitter conditions the field strength at a given distance over a smooth earth increases with the frequency, this effect is more than counterbalanced by the effect of the irregular terrain under conditions realized in practice. Thus, at the lower end of the frequency band (50–70 Mc./s.) there is little difference between median field strengths observed over irregular terrain and those calculated on the assumption that the earth is smooth. As the frequency is increased above 70 Mc./s., the observed median field strength falls more and more below the ideal theoretical values, the difference being as much as 20 db. at 700 Mc./s. The experimental work thus makes it possible to provide a simple empirical modification to the ideal smooth-earth propagation characteristics which will give the median field strengths to be expected over irregular terrain.

The discussion which followed the presentation of these papers showed that the conclusions are of considerable interest and importance to those who will be responsible for the development of future television and communication services at these higher radio frequencies.

SCIENTIFIC APPRAISAL OF SINGING VOICES

By Dr. FRITZ WINCKEL

Institut für Schwingungsforschung, Technische Universität, Berlin-Charlottenburg

WHILE it has long been possible to describe exactly the 'spectrum' of voices in speech, no detailed knowledge has hitherto been available about the spectrum of the trained singing voice, especially the timbre. In earlier investigations, the physical conditions were not exactly defined[1], and in particular the analyses made from normal records led to doubtful conclusions[2]. We have tested a considerable number of voices of well-known singers by electro-acoustic means, in order to obtain a better knowledge of the physical properties of trained singing voices. If, say, a singer is singing in a medium pitch of about 300 c./s. in mezzoforte, about ten partial tones are present. Each of these can be co-ordinated with a particular vowel quality and have a greater or less share in the full sound, depending upon the type of text, the pitch and the quality of the singing voice. By analogy with optics, these partial tones can be termed 'vowel colour' (*Vokalfarbe*). Thus the timbre of a trained singing voice can be distinguished from the 'flat' voice of an untrained singer by the fact that all vowel colours are available simultaneously in a certain modulation of intensity. Physically, the character of a good singing voice consists of the most favourable mixture of these vowel colours forming a 'complex colour' (*Komplexfarbe*). There are other features of importance; for example, a nasalizing region around about 2,000 c./s. (the so-called *Nasal-formant*) and a carrying region of about 3,000 c./s., which is thought to correspond to the active radius of the singing voice. In addition, there are other frequency regions which can be defined as 'metallic', 'hollow', 'sharp', etc.[3].

In a studio which is damped to the utmost, singers have a more pithy voice than in a resounding hall. This is explained by the fact that in a damped studio the trained functions are more active, since unfavourable autosuggestive influences through the ear and the central nervous system of the singer are avoided.

When testing singers' voices, the 'dynamic volume' has been measured by means of sound energy meters and an individual sound energy-level determined, a factor which has hitherto been overlooked by other investigators, leading to questionable results.

Deviations from the characteristic frequency properties of the singing voice indicate vocal disease or affections of the respiration organs. In co-operation with physicians a practical diagnostic method by analysis of microphone recordings has been worked out for application by ear, nose and throat specialists.

As a result of these investigations, the Technical University of Berlin-Charlottenburg has established a centre for voice estimation and training, to serve the purposes of teachers of singing and physicians. Magnetophone recordings of voices can be sent in for analysis: and the singer or patient receives a sound spectrum with an explanatory note. Such analyses have the documentary value of an X-ray photograph or electro-cardiogram.

A special instrument, called a 'repeater' (*Repetier-gerät*), has been developed by the Institute of Wave Research for the analysis of singing voices. The singer needs only to sing notes of short duration, which are lengthened by the repeater to continuous notes for analysis. Another important use of the repeater is in teaching. In the course of a considerable period of experiment, the Institute has tested in particular coloratura voices, by means of continual repetition of particular passages of the recording, for the qualities of 'attack', intonation, etc. This 'listening-in' to extracts of note sequences has often helped a student of singing to achieve a remarkable improvement in performance.

[1] Stanley, Douglas, "The Science of Voice" (Carl Fischer, New York, 1939).

[2] McGinnis, C. S., Elnick, M., and Kraichmann, M., *J. Acous. Soc. Amer.*, **23**, 440 (1951).

[3] Detailed information is given in *Folia phoniatrica*, **4**, No. 2, 93 (1952); **6**, No. 1 (1954).

SCIENCE AND MODERN COSMOLOGY

PROF. H. DINGLE delivered on February 13, 1953, his retiring presidential address to the Royal Astronomical Society, selecting "Science and Cosmology" as his subject, and the full text has now been published (*Mon. Not. Roy. Astro. Soc.*, **113**, 3; 1953). Prof. Dingle pointed out that in the earlier stages of science the world was so full of mysterious phenomena that there was no temptation to go outside experience in search of other realms; in addition, it became almost an intuition with scientists that at every stage they must submit their findings to the test of observation. While science then incurred little danger of violating its own principles, unfortunately this state of affairs does not always exist to-day, and in the realm of cosmology it has almost completely disappeared. The universe is no longer the observable world that was once the sole

object of astronomical study; on the contrary, it is, he said, "a hypothetical entity of which what we can observe is an almost negligible part". Assertions now made about it require observations over the remote past or over millions of years in the future, if they are susceptible of test at all, and hence speculation is inevitable; only strict adherence to the essential principles of science can control such speculations, and in cosmological studies a knowledge of the history and philosophy of science is most essential.

Prof. Dingle commented on a number of recent speculations by some cosmologists. Thus it has been stated that it is against the spirit of scientific inquiry to regard observable effects as arising from causes unknown to science, and that in principle this is what creation-in-the-past implies. Prof. Dingle said that confession of ignorance, far from being unscientific, is a characteristic of the scientific attitude, in support of which quotations are available from the works of Galileo and Newton. Perhaps the most extraordinary thing about the second statement, he continued, is that this idea of the creation of matter is just that which is opposed to the spirit of scientific inquiry—that the observable universe was created in the past by causes unknown to science.

Another statement claimed by Prof. Dingle to be fallacious is connected with an underlying assumption in experimental science; this assumption is that the repetition of an experiment will reproduce the original results. But experimental science is not based on an assumption; "it is an adventure in which you accept whatever you find, and although you may be guided in a particular case by an expectation, the experiment may reveal something totally different". An instance of this is found in the case of Schwabe, who counted sunspots with the object of finding an intra-Mercurial planet, and instead of doing so he found the eleven-year solar period. But if he had counted the spots with any other object or no object at all, he would still have found the eleven-year solar period; it would be futile to believe that the achievements of experimental science would necessarily lose all significance if it were discovered that some assumption proved baseless. In the realm of psychology it is accepted that no experiment when repeated produces the original result, and even in physics it has been held for a long time that no experiment is repeatable, the entropy of the universe never being twice the same.

A very severe criticism of 'the cosmological principle' and 'the perfect cosmological principle' advocated quite recently in some quarters was the next topic in Prof. Dingle's address. The evidence for these, he said, is practically non-existent, and he advocated a principle which, he thinks, will command universal assent: "No statement about the universe, or nature, or experience, or whatever term you prefer for the object of scientific investigation, shall be made . . . for which there is no evidence". At present we are faced with the rather disconcerting fact that any statement can be made about the universe if it cannot immediately be refuted; and if anyone is attracted by an idea for which there is no evidence, it is only necessary to call it a 'principle', no evidence being then required. When we are informed that matter is being continually created, but in such a way that the process is imperceptible, obviously the statement cannot be disproved; but when we ask why it should be accepted, we are informed that the fundamental axiom of science requires it. To avoid using names which he considers misleading, Prof. Dingle referred to the 'cosmological principle' as the "cosmological assumption" and to the 'perfect cosmological principle' as the "cosmological presumption".

Holding, as he does, that the object of scientific investigation is the world of experience or even experience itself, and that all advances in science consist either in enlarging the range of experience or in expressing the regularities found or to be found in it, Prof. Dingle has no place for the new doctrine that experience must conform to the tastes of the investigator. Equally he completely rejects its twin doctrine that experience must conform to a pattern which we can deduce by pure reason. The usual form of this latter doctrine is that the laws of Nature can be derived by reason without recourse to experience, but those who hold this view overlook the important fact that, by definition, laws of Nature are laws followed by what we experience and not by what we deduce from our axioms. A remarkable position in cosmology, he said, is that two impostors have usurped the throne of science, one of which is personal taste and the other is pure reason, and although they are not new, one of them—personal taste—has never before presented itself so brazenly. The reasons given by Prof. Dingle for this revival are traced to the theory of relativity—a very remarkable thing when we remember that the very essence of that theory lay in the recall of science to experience. The solution of certain problems of classical physics lay in the fact that some concepts had been assumed to be directly related to experience, but the assumption was incorrect. For example, it was proved that by no physical process is it possible to determine unambiguously the absolute simultaneity of separated events. Hence, to establish science on its proper basis—that of experience—such concepts were eliminated, and experience was described "in terms of those concepts alone which had a precise empirical meaning"; the error which was corrected arose from incomplete consideration of the effects of changing the co-ordinate system. This subject is fully dealt with in Prof. Dingle's address.

Towards the end of the address the attention of the new cosmologists was directed to biology, in which a problem somewhat similar to that confronting cosmologists arises: "We observe living matter and dead matter, but we never experience the creation of living matter out of dead matter alone". It may be assumed that in the past dead matter became alive by an unknown process, or we may suppose that the process has been going on eternally but at an undetectable rate. The first alternative is "against the spirit of scientific inquiry" according to the modern cosmologist, who presumably will be forced to postulate the continual animation of matter—a view which Prof. Dingle believes is ruled out by the cosmologists' own scheme. If the matter of which the earth is composed was created as separate atoms, it could not have begun to live for many millions of years, and hence terrestrial life must have begun at some particular epoch. To escape from the dilemma, the cosmologist must deny the existence of living matter—a most improbable attitude—or he must violate "the spirit of scientific enquiry".

Prof. Dingle concluded: "And so, when it happens that we have published, in the name of science, so-called 'principles' that, in origin and

character, are identical with the 'principles' that all celestial movements are circular and all celestial bodies immutable, it becomes my duty to point out that this is precisely the kind of cerebration that science was created to displace. . . . In cosmology we are again, like the philosophers of the Middle Ages, facing a world almost entirely unknown".

NATIONAL RESEARCH DEVELOPMENT CORPORATION: CONTINUATION OF BORROWING POWERS

THE Development of Inventions Bill, as foreshadowed in the fourth annual report of the National Research Development Corporation (see *Nature*, February 6, p. 249), received its second reading in the House of Commons on January 26. The Corporation's borrowing powers under the 1948 Act expire on June 30, 1954, and the Bill extends from five to ten years the period during which advances may be made to the Corporation and payment of interest on such advances waived. Numerous tributes to the work of the Corporation were paid during the debate, and in moving the second reading of the Bill, the President of the Board of Trade, Mr. P. Thorneycroft, explained the purposes of the clause which slightly extends the scope of the Corporation's activities. There appeared to be some doubt as to whether under the original Act the Corporation was empowered to carry out research for the purpose of developing an existing invention if this should lead to a substantially new invention. The first sub-section of Clause 2 of the new Bill is intended to remove this doubt and authorizes the Corporation to promote or assist any research likely to further the development or exploitation of inventions or to enhance their value.

The second sub-section of this same clause, Mr. Thorneycroft explained, arose from a comment in the last report of the Advisory Council on Scientific Policy as to the desirability of extending the existing organization for the use of research and development contracts. The sub-section authorizes the Corporation to promote and assist research intended to satisfy specific practical requirements where the Corporation believes the research is likely to lead to an invention, while a further sub-section of the clause empowers the Corporation to assist the continuation of a research which hitherto has proved fruitless from a practical point of view but which appears likely to lead to practical results. Exercise of its functions under these two sub-sections is subject to the approval of the Lord President of the Council and of the President of the Board of Trade.

Mr. Thorneycroft explained that this proviso was introduced to avoid the overlapping of the work of the Corporation and that of the universities, of other government departments or of research organizations like the Medical Research Council or the Department of Scientific and Industrial Research. He also stressed the point that the Corporation's task is to promote and assist research. It is not primarily to undertake research, he said, and is never to undertake it in competition with industry or with other government departments. When the Bill received its third reading on February 1, the Parliamentary Secretary to the Board of Trade added further that it was never intended to give the Corporation general powers to undertake surveys or investigations to discover the practical needs of industry. That, he said, can best be done by industry itself, though possibly with the help and encouragement of government departments and at the suggestion of the National Research Development Corporation. Once such an investigation has established the prospect of industrial benefit, the powers to be given to the Corporation will enable it to take the responsibility for getting the required research done.

Two comments which were made during the debate on the second reading of the Bill are of particular interest. Mr. John Edwards, in welcoming the Bill, pointed out that the National Research Development Corporation is now inevitably involved in the provision, in a modest way, of risk capital, and he thought that the Bill would enable the Corporation to make a further contribution towards restoring a balance between the proportion of the resources devoted to fundamental research and those devoted to development. Mr. Austen Albu, who estimated the total expenditure during 1951 in Britain on research and development to be £268 million, of which £70 million was for civilian research, stressed the need to stimulate backward industries and to avoid overlapping. In some research associations, he said, there is a belief that projects in their field are sometimes undertaken in government establishments; and Mr. H. Strauss assured him that the reference to the President of the Board of Trade and the Lord President of the Council was designed simply to prevent such overlapping.

COMMONWEALTH FUND, NEW YORK

REPORT FOR THE YEAR 1952–53

THE thirty-fifth annual report of the Commonwealth Fund* covers the year ending June 30, 1953, and deals primarily with the activities for which grants were made during 1952–53. For medical education appropriations during the year totalled 602,977 dollars, for experimental health services and hospital activities 224,323 dollars, for medical research 517,101 dollars, for advanced fellowships in medicine and allied fields 75,000 dollars, for the Division of Education 310,050 dollars, and a special grant of 2,750,000 dollars was made for the construction of a dormitory, to be known as the Edward S. Harkness Memorial Hall, for medical students at Yale University. Actual disbursements during the year from current and previous appropriations totalled 2,584,179 dollars. Among the nine projects in medical education for which new or renewed appropriations were voted are a programme at Cornell University Medical College to provide students with a wider experience in medical care through continuity of contact with patients; grants to the University of Pennsylvania School of Medicine for the continuance of its family adviser programme until it is fully incorporated in the University framework, and for a year's pilot-study of the medical school as an educational environ-

* The Commonwealth Fund. Thirty-Fifth Annual Report for the Year ending June 30, 1953. Pp. x+38. (New York: Commonwealth Fund, 1953.)

ment; a revised teaching programme at the Medical School of Western Reserve University, in which a systematic effort is being made to correlate basic science subjects with clinical ones; and further support to the study of psychiatry and its relation to medicine at Washington University, the University of Louisville and the Saskatchewan Department of Public Health.

The Fund continued its support of the major experiment in integrated health care in Hunterden County, New Jersey, where a medical centre that was opened in June 1953 is testing the theories of its long-term planning. A further grant to Hunterden was for a county-wide health inventory, and a grant was made to the Rip Van Winkle Foundation towards the development over three years of a mental health programme for Columbia County. Another grant went to the National Opinion Research Centre in Chicago for the completion of its national survey of opinion about mental health and illness, and support was also given to the qualitative study at the Yale Psychiatric Clinic of the effect of interactions between patients and staff and between the different ranks of staff on the daily life and therapeutic effectiveness of a psychiatric ward.

During the year the Fund reviewed its interests in the field of medical research to which over seven years it has given nearly three million dollars for fifty-seven projects. Projects for which support was discontinued were largely in the fields of infectious disease, cardiovascular disease and cancer research, where major support is now received from other sources. Current research grants cover nine projects, one of which was new in 1952–53, and are in three categories: the first, which is primarily concerned with interaction between organism and environment, includes studies of growth and personality development, certain types of neuro-psychiatric research and studies of relations between social environment and chronic disease; the second deals primarily with integrative processes within the organism and includes studies of the neurological and endocrine systems and their relations; and the third is weighted in favour of basic biological studies.

Advanced fellowships awarded during the year included four in medicine or surgery, one for advanced work in psychiatry, and five for interdisciplinary studies as well as two fellowships to foreign workers. The programme of fellowships offered to British graduates, journalists and Civil servants for study and travel in the United States was broadened in 1952 to include persons on the Continent of Europe by a series of awards for candidates from the Salzburg Seminar in American Studies. Forty-nine Fellows in all categories were in residence in the United States during the year beginning September 1952, including nine British Fellows of the 1951 class who were granted extensions. For the present year, fifty-nine Fellows will be in residence, including thirty-seven on new awards and seventeen on extensions, the two-year figures including sixteen 'Salzburg' Fellowships. For the latter the Fund has been experimenting with a new plan of selection in which it has been possible to make nominations after a month's daily experience with the participants. Experience over the years is heavily in favour of the tenure of at least one full year, including two or three months of travel in the United States, and stress is laid on the value of the fellowships in developing leadership, and also in encouraging the exchange of ideas and information.

DEFENCE STANDARDS LABORATORIES, AUSTRALIA

REPORT FOR THE YEAR 1952–53

SINCE the transfer to other sections of the Research and Development Branch of the Department of Supply, Commonwealth of Australia, of research and development work on new weapons, the Defence Standards Laboratories, which have now been incorporated in the Research and Development Branch, have concentrated on scientific advisory service, and the Chief Superintendent's annual report* for the year ended June 30, 1953, indicates the new functions and scope of the Laboratory. Broadly, they are the application of scientific knowledge and research in chemistry, physics, metallurgy and engineering to problems arising in design, development, manufacture, inspection, storage and use of defence material. They include the provision of a scientific advisory service and the research required to provide a sound basis for such service. Its standardizing work is based on sub-standards verified in terms of the national standards held by the National Standards Laboratory, Sydney, and the staff also participate in specification drafting work of the Standards Association of Australia. The testing work involves the use of an extensive range of measuring instruments of proved accuracy.

Among investigations to which reference is made in the present report are detailed studies of the direct production of polymeric butyl titanate on a pilot-plant scale, giving yields of more than 80 per cent. Pigmentation of this polymer with zinc dust gives a paint with outstanding anti-corrosive properties, particularly under marine conditions, and anti-fouling paints based on such polymers pigmented with copper oxide and mercuric oxide are also being developed. Further progress has been made in the study of indigenous drying oils, and five new paint-exposure sites were brought into use during the year. Oxidation tests and the oxidizing characteristics of mineral oils are being studied with the view of establishing tests for identifying the type of an oil, and studies are being made of type and degree of damage in flax, jute and sisal fibres due to fungal and other agencies. The ebullioscope method of determining the molecular weights of polymers has been used extensively in the preparation of polymers of butyl titanate and styrene, and some experience was gained in the preparation of cellular (foamed) plastics.

In metallurgical chemistry a rapid test was developed for detecting porosity in nickel coatings on zinc-base die coatings, and much work was done on anodic passivation phenomena encountered in the anodic etching of low-alloy steel in dilute sulphuric acid. Chromate has proved to be a satisfactory inhibitor of corrosion in a spray-tower heat-exchanger circuit, and work was completed on some aspects of the mechanism of corrosion inhibition on mild steel in dilute sulphuric acid solution when very small amounts of organic inhibitors are added. A modified procedure was developed for determining phosphorus in all classes of iron and steel. In crystal physics more attention is now being given to long-

* Research and Development Branch of the Department of Supply, Commonwealth of Australia. Annual Report of the Defence Standards Laboratories for the Year ended 30th June, 1953. Pp. 56. (Maribyrnong, Vic., Alexandria, N.S.W., and Finsbury, S.A.: Research and Development Branch, Department of Supply, 1953.)

range research, particularly the application of X-ray diffraction in metal physics, including the influence of prior deformation on the structural changes associated with the creep of high-purity aluminium, and a detailed study of the structural changes during the tertiary creep stage in this metal. A complete structure analysis has been made of the fibrous silicate, amosite.

The Electricity Group has developed a microwave spectrograph for analysing the molecular structure of gases and has continued investigations on the scattering of electrons from solids, where the electrostatic analyser holds most promise of success in measuring the energy distribution. In optics the Zernike phase-contrast test, the Johnson–Scholes interferometer and the Bates sheared-wave interferometer have been added to existing techniques for testing optical surfaces, while an experimental Schmidt–Cassegrain objective, 50 in. in focal length, is being developed. The technique of making metal bolometers of small time-constant to function as infra-red receivers has been developed further, while in physical metallurgy investigations into the behaviour of metals in service have included studies of inter-crystalline corrosion in aluminium alloys. In welding metallurgy, much useful information on brittle failure, strain ageing, quench ageing and residual welding stresses has been accumulated.

An investigation is now being undertaken into variation of pore-size, specific surfaces and general adsorption capacity of a series of sulphur-impregnated activated charcoals.

Details of the work of the New South Wales and the South Australia branches are included, and lists of publications and lectures, of committees and of senior and professional staff at June 30, 1953, are appended.

ENERGY TRANSFER IN MACROMOLECULES EXPOSED TO IONIZING RADIATIONS

By Dr. P. ALEXANDER

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In gases there is abundant evidence[1] that the energy absorbed from ionizing radiations by one molecule can appear in another by transference of charge and excitational energy. In aqueous solution the energy absorbed by the water causes a change in the solute; since this process is now known to be brought about through the intervention of free radicals, the general term of energy transfer need not now be applied to these reactions[2]. Recently, Manion and Burton[3] found that the decomposition of cyclohexane was decreased in the presence of benzene, which presumably took up the energy from the excited or ionized cyclohexane molecule before this had dissociated. In all these cases collision between the molecules concerned is possible and, though there is no difficulty in principle, there is only limited evidence[4] that energy from ionizing radiations can be transferred within solids when the molecules are relatively immobile. A related effect is the transfer of energy within the same macromolecule from one part to another. Svedberg and Brohult[5] observed that the giant molecule hæmocyanin is split into identical parts by the traverse of a single α-particle, although the density of ionization makes it extremely unlikely that a single ionization can occur at a given site. This highly specific behaviour can be understood if energy absorbed anywhere within the giant molecule is mobile and able to break the bonds which hold the sub-units together. The smaller proteins which have been examined do not react in this manner but are degraded at random by α-particles to give a heterogeneous product. The following experiments with synthetic polymers provide direct evidence for energy transfer in saturated macromolecules of different constitution.

Polymethylmethacrylate is degraded at random by γ- and pile-irradiation, and from the simple function relating molecular weight with radiation dose it could be computed that one main-chain bond was broken for every 61 eV. energy absorbed[6]. This energy is not used only for main-chain breakdown but also includes associated reactions, such as decomposition of the ester side-chain, which occur simultaneously. When films of polymer containing 10 per cent of allylthiourea, aniline or di*meta*-tolyl-thiourea were irradiated, 143, 152 and 227 eV. respectively had to be taken up by the system before a main-chain bond was ruptured. This protective effect, occurring in a system where the action of the radiation is 'direct', is now being studied in detail by Mr. D. Toms, whose preliminary experiments indicate that over a wide range protection is approximately independent of dose and proportional to the concentration of the added substance. The amount of radiochemical change which the latter undergoes is greater in the presence of the polymer than when it is irradiated alone. It seems likely, therefore, that the protection of the polymer is the result of energy transfer to the added substance. Since the area of the polymer molecules which is in physical contact with the additives can only be small, energy absorbed by ionization or excitation must be distributed over comparatively long distances before it can be taken up by the protective agent.

Poly*iso*butylene, like polymethylmethacrylate, is degraded by γ- and pile-irradiation, and from changes in molecular weight a value of 17 eV. was obtained for the energy absorbed per break in the main chain[7]. A co-polymer of 20 per cent styrene and 80 per cent *iso*butylene (kindly provided by Dr. Butler, of the Polymer Corporation, Canada) is more resistant than the pure *iso*butylene, and the energy required to break a main chain is increased approximately twice to 32 eV. The protection in this case can be interpreted as energy transfer from the *iso*butylene part of the chain to the aromatic ring system of the styrene, in which the energy is dissipated with only a very small amount of chemical change[8].

In a similar way, the dose required to render a straight-chain hydrocarbon infusible (that is, to cross-link it to give an infinite network) is greatly increased by the presence of an aromatic ring. Cross-linking is the predominant reaction[9] when straight-chain hydrocarbons are irradiated, and there is little, if any, chain breakdown. Although the energy required to produce a cross-link (*c.* 20 eV.) is independent of chain-length, the dose needed to render a

DOSE IN PILE UNITS* REQUIRED TO RENDER SUBSTITUTED DODECANES INFUSIBLE

Substituent	1-dodecane	4-dodecane	6-dodecane
1′ naphthyl	43	—	—
2′ naphthyl	43	62	66
2′ decalyl			37

* The pile unit is defined as a flux of 10^{17} slow neutrons/cm.^{2} plus the associated γ-rays and fast neutrons. Comparison of cross-linking and degradation produced in the pile and by γ-rays from a cobalt unit indicates that one unit is equivalent to $4{\cdot}5 \times 10^7$ r. for these reactions.

The compounds were kindly provided by Dr. B. Eisner, of the Dyson Perrins Laboratory, Oxford.

hydrocarbon infusible varies inversely as the molecular weight, since an average of one cross-link per molecule (weight average) is required for this change to occur. To render dodecane infusible, 27 units of pile-irradiation are required.

The addition of the saturated polycyclic hydrocarbon decalin at the centre of the paraffin molecule increases the dose slightly, whereas the presence of the aromatic naphthalene ring may render the straight chain much more difficult to cross-link, although any steric factors which could influence the reaction will be very similar in the two cases.

Since the amount of energy absorbed by the paraffin chain is not altered by the addition of other groups, we must conclude that the energy has been transferred to the aromatic ring before it could bring about the chemical changes leading to cross-linking. The table shows that maximum protection occurs when the aromatic ring is at the centre of the paraffin chain, and that the effect is smallest at the end. This suggests that energy transfer can occur along a saturated chain of twelve carbon atoms, but that it is more effective over shorter distances. The data indicate that the saturated ring exercises a small protective effect and that it contributes nothing to the cross-linking, since the corresponding C_{22} straight-chain paraffin, because of its higher molecular weight, required only 12·3 units to be rendered infusible.

The occurrence of energy-transfer processes in organic macromolecules may play an important part in the biological actions of ionizing radiations, since, as we have shown here, such transfers can result both in a decrease of total reaction by concentrating the energy in a group resistant to radiation, or by the preferential decomposition of a particular component. For example, the possibility can now be envisaged of protecting against a 'direct effect', since macromolecules need not decompose immediately on becoming ionized and can transfer their energy without undergoing reaction if a suitable receptor is present. Consequently, it cannot be concluded that any effect against which protection can be achieved by the addition of chemicals must invariably be the result of reactions with free radicals produced in the surrounding medium.

For the smaller viruses, Lea[10] had found that an ionization anywhere within the organism leads to inactivation. The conclusion that every part of the virus was equally vulnerable is in contradiction to biochemical experiments, which had shown that many groups of the macromolecule could be modified without loss of activity. The results reported here indicate that the difficulty may be resolved if the target represents the distance over which energy transfer can take place, whereas the sensitive region is smaller. If this view is accepted, 'direct' and 'indirect' are not fundamentally different, but represent merely two different mechanisms by which energy provided by ionizing radiations to the system as a whole is concentrated at definite points. The reactions produced in a complex structure by direct transfer of energy may be more selective than those brought about by the indirect action of highly reactive free radicals, and this may explain the much higher efficiency of direct action for the inactivation of viruses[11].

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AFTER-EFFECTS OF X-IRRADIATION OF DEOXYRIBONUCLEIC ACID

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THE change of viscosity of deoxyribonucleic acid (DNA) brought about by X-irradiation was shown by Taylor, Greenstein and Hollaender[1] to continue long after the termination of the irradiation. Butler and Conway[2] found that after irradiation of deoxygenated solutions of DNA the viscosity remained nearly constant after a small initial fall during the first hour or two. They therefore concluded that the 'slow' after-effect, following irradiation in oxygen, was due to a product of the primary radicals with molecular oxygen. Possible products are HO_2 radicals and molecular H_2O_2, and it was shown that hydrogen peroxide, although present and responsible for some of the after-effect, was not capable of accounting for the whole of it. It was suggested that the remainder of the effect might be due to the slow decomposition of peroxidic derivatives of the nucleic acid.

Recently, Daniels, Scholes and Weiss[3], using slightly different experimental conditions, observed an after-effect in deoxyribonucleic acid solutions irradiated *in vacuo*, which was about one-third of

that found with oxygenated solutions. They therefore suggested that the effect of oxygen was merely an enhancement of an effect which already occurred in its absence, namely, the slow hydrolysis of deoxypentose-phosphate internucleotide links made labile by oxidation by the radicals at the C_4' position on the pentose[4,5]. The enhancement of this effect by oxygen they supposed to be due to elimination of back reactions, thus leading to an increased oxidation yield.

I have made experiments to ascertain the cause of this discrepancy between the results of Daniels, Scholes and Weiss[3] and those of Conway and Butler[2,6].

Solutions of a highly polymerized specimen of DNA (0·1 per cent) were prepared *in vacuo* in an all-glass apparatus, in which water was distilled *in vacuo* into ampoules containing the DNA, from a vessel in which it had been previously deoxygenated by refluxing at atmospheric pressure in argon, made oxygen-free by passage through alkaline pyrogallol, and then over copper gauze heated to about 450° C. and finally through a trap in a solid carbon dioxide – ethanol mixture. The ampoules were detached and the deoxyribonucleic acid allowed to dissolve for about 36 hr.: the solutions were then irradiated with 140-kV. X-rays (half-value layer thickness 0·04 mm. copper) to give a dose of 10,000 r. at 166 r./min. Oxygenated solutions were prepared by bubbling oxygen through the solution for 15 min. immediately prior to the irradiation. The viscosity of the solutions was measured as soon as possible after the termination of the radiation in Frampton type viscometers at shear-rates between 50 and 250 sec.$^{-1}$. When the experiments were carried out under these conditions, I was able to reproduce the observations of Daniels *et al.*[3]; I examined a number of factors such as shaking the solutions for 12 hr. before radiation, introducing various types of grease, keeping the solutions in argon or nitrogen instead of *in vacuo* during the irradiations, but so long as the viscosity was measured directly (see below) on the irradiated solutions an after-effect of about one-third of that found in oxygen was usually observed (Fig. 1). However, when the experiment was carried out under the conditions which we used in our earlier work[2,6], namely, irradiation of solutions at 0·2 per cent concentration, followed by dilution to 0·1 per cent with twice-distilled water immediately after the irradiation and before the viscosity measurements were commenced, the after-effect *in vacuo* was largely suppressed and was no greater than the slow change of viscosity which occurred after diluting a 0·2 per cent solution to 0·1 per cent. When the 0·2 per cent irradiated solutions were diluted, 1 : 1, with 0·1 *N* sodium chloride the viscosity was quite constant for 48 hr. (Fig. 2). Dilution, either with water or 0·1 *N* sodium chloride, of the 0·2 per cent solutions irradiated in oxygen did not eliminate the after-effect. The discrepancy in the results thus appears to be due to the fact that Daniels *et al.*[3] measured viscosities of the solutions as irradiated, whereas Conway and Butler, for reasons of experimental convenience, diluted their solutions × 2, after irradiation before the viscosity measurements were commenced.

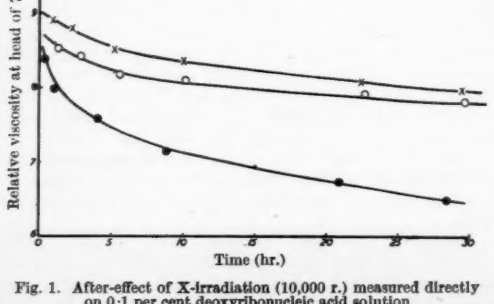

Fig. 1. After-effect of X-irradiation (10,000 r.) measured directly on 0·1 per cent deoxyribonucleic acid solution
○, *in vacuo*; ×, *in vacuo* with grease; ●, in oxygen

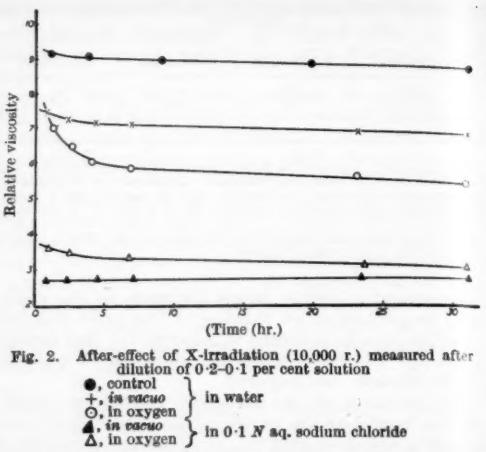

Fig. 2. After-effect of X-irradiation (10,000 r.) measured after dilution of 0·2–0·1 per cent solution
●, control; +, *in vacuo*; ○, in oxygen — in water
▲, *in vacuo*; △, in oxygen — in 0·1 *N* aq. sodium chloride

The fact that the *in vacuo* after-effect can be largely eliminated by dilution raises the question whether the slow changes observed in this case in non-diluted solutions can be attributed to a chemical process at all, for example, to the slow hydrolysis of labile internucleotide linkages (see above) as suggested by Scholes and Weiss[4,5].

The viscosity of solutions of deoxyribonucleic acid at moderate concentrations is largely due to the interactions between the particles[7,8] and is not related in a simple way to the length of the polynucleotide chain. It is possible to destroy the abnormal high viscosity without any appreciable change of molecular weight[9]. Viscosity changes cannot, therefore, be taken as solely due to breakages of the nucleotide chain resulting from the oxidation of the sugar; various lines of experimental evidence show that viscosity changes can occur by changes in the intramolecular hydrogen-bonding and in intermolecular interactions.

The elimination of the after-effect by dilution suggests that in the experiments without dilution the after-effect is largely the result of a slow readjustment or equilibration of the interactions between the particles due to their modification in shape, size and charge by the chemical processes occurring during the irradiation. Dilution with water or salt solution presumably immediately introduces much larger changes of interaction between the particles, so that the slow effects which would otherwise be apparent are no longer significant.

With regard to the large after-effect produced by irradiation of oxygenated solutions, the mechanism is complex; it is an undoubted fact that: (1) hydrogen peroxide is formed; (2) hydrogen peroxide is

capable of degrading irradiated deoxyribonucleic acid[6,10]. In the mechanism of the after-effects discussed by Daniels *et al.*[3], this effect of hydrogen peroxide in the oxygenated solution has not been considered. It is quite possible that some part of the after-effect observed in oxygen is due to slow hydrolysis of sugar phosphate groupings labilized by oxidation at the C_4' position as Scholes and Weiss suggest.

However, the suggestion by these authors, that in oxygen the formation of unstable peroxidic intermediates of the deoxypentose in nucleic acid may be more important than direct oxidation by OH radicals, is not unlike our own[2,6,10].

It seems likely that all three processes, namely, the formation of labile phosphate esters, the slow decomposition of peroxide intermediates and the interaction of hydrogen peroxide, formed during the irradiation in oxygen, with the deoxyribonucleic acid damaged by radiation[10], may be involved simultaneously in the after-effect observed in oxygenated solutions. The recent proposal by Watson and Crick[11] of a double-chain helical structure for deoxyribonucleic acid, in which the chains are held together by hydrogen bonds between the heterocyclic bases, makes possible the consideration of another type of process which might occur slowly after initial damage to the chains by certain radicals. If the chains of a linked pair are broken at some points not immediately opposite one another, and some damage, for example, a deamination, ring fission, etc.[4,12], is caused to the bases, a slow rearrangement such as untwining or collapse of the helical rod-like structure might occur during a period of time after the initial damage.

It might have been expected, on the theory advanced by Daniels, Scholes and Weiss, that if the greater after-effect in oxygen is due to an enhanced oxidation, the *primary* effect of irradiation would also be greater in this case. Daniels *et al.* state, however, that the primary effect of irradiation in oxygen is *less* (about 50 per cent) than that *in vacuo*. It is not easy to see how they reconcile this observation with their theory; their results could only be explained if it is supposed that hydrogen atoms are much more effective in immediate depolymerization of deoxyribonucleic acid than the HO_2 radicals formed from them in oxygenated solutions. In our own experiments, on the other hand, it has consistently been found that viscosities measured very soon after irradiation *in vacuo*, nitrogen or oxygen are closely similar, in agreement with the observations of Smith and G. C. Butler[13], and Limperos and Mosher[14].

A further experiment has been designed especially to test this point again. 0·1 and 0·2 per cent solutions of deoxyribonucleic acid were made up *in vacuo* in one limb of double ampoules in the form of an inverted U. When the nucleic acid was dissolved completely, the solution was divided equally between the two ampoules by tipping the U-tube. This procedure was used in order to make the comparison on identical solutions, since some variations occur in the viscosity of solutions of deoxyribonucleic acid of the same concentration made up separately at different times. The solution in one side of the double ampoule was then irradiated, still *in vacuo*, with 10,000 r., while the other limb was shielded in a thick lead pipe. After the radiation, the viscosity of the solution was measured between 50 and 250 sec.$^{-1}$ in the Frampton viscometer. Oxygen was then passed into the second half of the solution contained in the other ampoule, and this was then

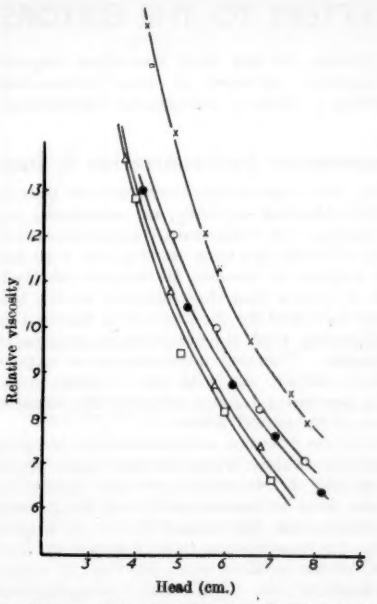

Fig. 3. Primary effect of X-irradiation (10,000 r.) *in vacuo* and oxygen
×, control; ●, 0·1 per cent *in vacuo*; ○, 0·1 per cent in oxygen; ⊡, 0·1 per cent after dilution from 0·2 per cent, *in vacuo*; △, 0·1 per cent after dilution from 0·2 per cent, in oxygen

irradiated similarly and its viscosity determined. After the irradiation, the viscosity of the solution irradiated *in vacuo* was only 4 per cent less than that of the solution irradiated in oxygen (Fig. 3). We cannot, therefore, agree that the primary effect in oxygen is greatly different from that *in vacuo*, as maintained by Daniels, Scholes and Weiss. These results suggest, then, that the after-effect in oxygen is due mainly to distinct processes not involved to any great extent in the primary effect in either oxygen or *in vacuo*.

Acknowledgments. I wish to thank Prof. J. A. V. Butler for his interest in the work and for many helpful discussions and suggestions, and Dr. L. F. Lamerton for providing facilities for carrying out the X-irradiations. This investigation has been supported by grants to the Royal Cancer Hospital and the Chester Beatty Research Institute from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service. [Dec. 29.

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LETTERS TO THE EDITORS

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Temperature Acclimatization in Insects

Among the voluminous literature on temperature and poikilothermal activity, an occasional paper is found dealing with temperature acclimatization. The majority of work has been carried out with fish.

With respect to insects, Mellanby[1,2] showed for a number of species that their activity at low temperatures was modified by their previous thermal history, thus indicating that insects became acclimatized to temperature. Thermal acclimatization experiments have been carried out with the German cockroach, *Blattella germanica* L. and some of the experimental evidence is presented below.

The relation between acclimatization temperatures and activity at low temperatures above freezing is shown in Fig. 1. It is evident that insects kept at 15° C. are able to remain active at temperatures at which others from 25° C. and 35° C. are immobilized by cold. Acclimatization to cold is not an unlimited process, which is illustrated in Fig. 2, where cold immobilization or 'chill-coma' temperatures are plotted against their corresponding acclimatization temperatures. The 'chill-coma' temperature of *B. germanica* acclimatized at 10° C. is the same as for those acclimatized at 15° C. This suggests that acclimatization is only possible within a certain temperature-range.

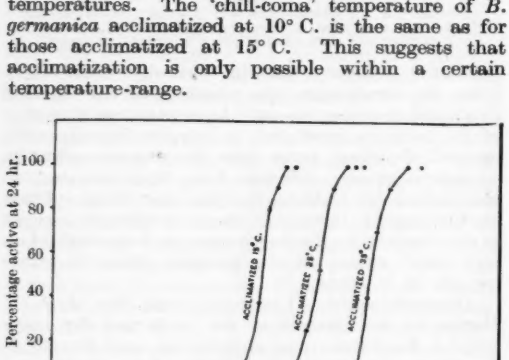

Fig. 1. Relation between acclimatization temperatures and activity at low temperatures for males of *B. germanica*

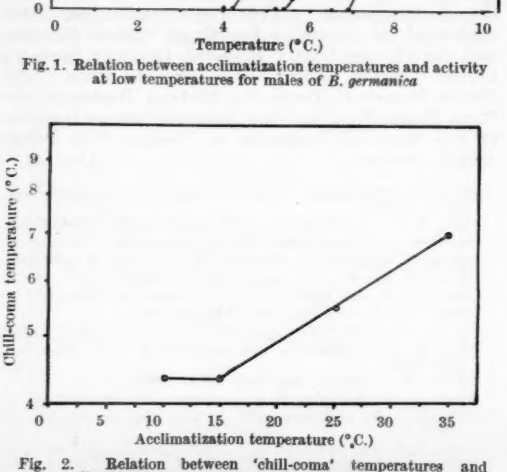

Fig. 2. Relation between 'chill-coma' temperatures and acclimatization temperatures for males of *B. germanica*

Experiments have also been carried out on survival at 7° C. of *B. germanica* acclimatized at 35° C., 25° C. and 15° C. Insects from 15° C. lived longer than those from either 25° C. or 35° C.; the 35° C. group died most quickly. This implies that much of the previous work on cold-death points at temperatures above freezing is invalidated. The cause of death at low temperatures is unknown, but insects immobilized by cold for a given period showed signs of a nervous disturbance which was not reversible.

This and other phases of the work will be published more fully elsewhere.

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Acclimatization and the Thermal Death Point in Insects

Insects, like other cold-blooded animals, are active over a range of temperature, limited below by the chill coma point, and above by the heat coma point (closely related to the thermal death point, that is, the upper lethal temperature, for they cannot recover from long periods of heat coma). On the whole, the heat coma point is higher for insects from warm regions, and the chill coma point is lower in those from cool regions.

The chill coma temperature can be readily altered. I showed some years ago that in a number of species exposure for as short a period as 24 hr. to warmer or cooler conditions within the normal range will modify the chill coma point substantially, in some species by as much as 7·5° C.[1,2].

I now find that the heat coma point and the thermal death point can similarly be rapidly changed by keeping insects at different temperatures for periods of only 20 hr.; longer exposure gives no further adaptation. Thus, in the mealworm, *Tenebrio molitor*, larvæ from cultures kept at 37° C. for 24 hr. have a thermal death point, for a one-hour exposure, of 44° C.; those kept at 30° C. or below have a thermal death point of 42° C. The results for larvæ of the mosquito *Aedes aegypti* are very similar. Two facts are apparent when these results are compared with the low-temperature experiments: (*a*) the range over which the thermal death point can move is much smaller than that over which the chill coma temperature can be changed; (*b*) substantial changes in the thermal death point are caused only by previous exposures to temperatures towards the top of the range over which the insects can survive, whereas low-temperature adaptation occurs over the whole range.

Insects acclimatized to high temperatures thus survived exposures which killed unacclimatized insects. It was noticed, however, that they did not continue their development and moult or pupate at the same time as unheated controls. It seems that sublethal exposures to heat may destroy the internal secretions which control these processes. I showed[3] that if the blow-fly larva *Lucilia sericata* is kept at a high temperature for several days it goes into diapause, while controls pupate. Wigglesworth[4] has similarly shown that at temperatures above the optimum the bug *Rhodnius prolixus* does not moult.

The experiments described here show that much briefer exposures to high temperatures interrupt development, but that after a delay (of perhaps a month in *Aedes*) normal pupation occurs and adults are then produced after the usual interval.

This extended life-history in insects may be of practical importance. In Nature, insects may often be exposed to temperatures similar to those used in these experiments, and if this causes a substantial prolongation of the life-history, it may give rise to unexpected emergences of insects which are important vectors of disease or pests of stored products.

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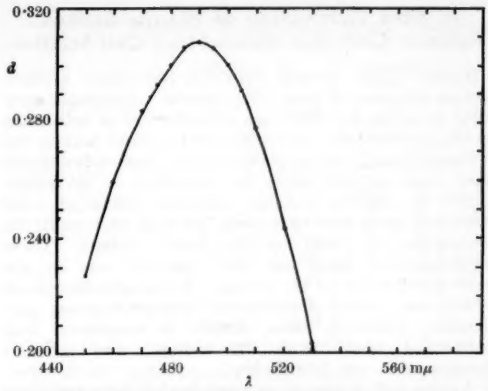
An Acidogenic Carotenoid in a Bathypelagic Nemertean Worm

CERTAIN brightly coloured littoral nemerteans contain carotenoids, and it is likely that most deep-sea species of similar coloration likewise store this class of biochrome[1].

Recently, there arose a rare opportunity to examine briefly the red-orange pigment from three freshly collected specimens of *Nectonemertes mirabilis* Verrill (one immature male and two females, 30–34 mm. long and 5 mm. wide). These were taken in a depth haul from 1,200 m. to the surface in the Santa Barbara Passage off the coast of Southern California by Dr. N. T. Mattox at the Allen Hancock Foundation, and were presented to Prof. W. R. Coe of the Scripps Institution, who identified them as members of this widely distributed species, usually encountered at depths from 500 m. down, in the North and the South Pacific Ocean.

The specimens, fixed in dilute formalin, then preserved in 70 per cent ethanol, were examined within a week after capture. The deep red-orange pigment was concentrated in oil droplets in the digestive diverticula. In view of the unlighted habitat and the microcrustacean diet of this worm, it was of special interest to learn whether, as in numerous other marine carnivores, its richly stored pigment might belong to the oxygenated carotenoids[1].

The preserved worms had lost none of their bright colour, but substitution of absolute ethanol readily leached the pigment out, imparting a red-orange colour to the solvent and leaving the animals quite pale. The pigment was completely epiphasic, migrating quantitatively from the alcohol into light petroleum to give a yellow solution. However, after an hour's exposure to warm ethanolic potassium hydroxide, the pigment showed quantitative hypophasic behaviour, thus reflecting the absence of carotenes and the original presence of esterified xanthophylls. Dilution effected the migration of a trace of yellow pigment into the petroleum, while the more copious red component now separated as a potassium salt at the liquid interface. In its preferential solubility in alcohol, and in its reversible transference from alkaline or neutral alcohol to petroleum,



Absorption curve of acidic carotenoid derived from an ester occurring in *Nectonemertes mirabilis* Verrill

the yellow component behaved like a neutral xanthophyll. Its quantity was insufficient for further study.

The red interfacial salt was washed with additional petroleum and was then readily dissolved in this solvent containing a little acetic acid. The yellow petroleum solution displayed, on shaking with water, the transient pinkish emulsion which characterizes other acidogenic carotenoids, such as astacene and metridioxanthin[2]. The acid-free petroleum solution was evaporated in an inert atmosphere and the deep orange residue was dissolved in redistilled pyridine (b.p. 114–116° C.). This red-orange solution exhibited a single, discrete absorption peak whose steep, symmetrical shape and maximum at 490 mμ differentiated it from astaxanthin or its artefact, astacene, which show a less sharp maximum at 500 mμ in the same solvent (Beckman photoelectric spectrophotometer; see accompanying figure). In its spectrum the nemertean pigment recalls a similar acidogenic carotenoid from the marine shrimp *Hippolyte*[3] and another from the anemone *Metridium*[4].

Evidently this deep-sea pelagic ribbon-worm owes its bright red-orange colour to the presence of an acidogenic carotenoid ester, related to but not identical with astaxanthin. The principal carotenoid and the accompanying traces of esterified neutral xanthophyll doubtless originate from the animal's consumption of planktonic crustaceans and other pelagic fauna. The finding of rich stores of oxygenated carotenoids, unaccompanied by any carotene hydrocarbons, adds to the growing list of xanthophyll-selecting marine carnivores[1], a widely occurring species the habitat of which is limited to great oceanic depths.

I acknowledge the generosity and help of Prof. Wesley R. Coe, and the welcome co-operation of Dr. Norman Millott in conducting the spectroscopic examination.

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In Vitro Cultivation of Mouse Ascites Tumour Cells for Virus–Host Cell Studies

Klein[1,2] has found that the so-called Ehrlich ascites tumours of mice offer several advantages over solid tumours for studying the effect of a substance on the growth-rate, on nucleic acid content and on the cytomorphology of neoplastic cells. These advantages have been applied lately by a number of investigators[3,4] to studies dealing with the effect of viral infection upon the neoplastic process and with the adaptation of virus to the ascitic cells[5]. These investigations have all been carried out in the peritoneal cavity of the mouse. An *in vitro* technique which may prove feasible for similar studies, particularly host-cell virus studies in neoplastic cells cultivated apart from the animal, was recently developed in our laboratory.

Ascites cell suspensions were freshly removed from tumorous Webster-strain white mice, centrifuged at 2,000 r.p.m. for 15 min. and the supernatant decanted. The cells were then resuspended in a nutrient medium composed of 50 per cent ox serum ultrafiltrate, 10 per cent chick-embryo extract and 40 per cent Hanks's balanced salt solution with 0·002 per cent phenol red indicator. Two hundred units of penicillin and 100 μgm. of streptomycin were added at first to preclude contamination. 1-c.c. aliquots were dispensed into Porter flasks in which were incorporated glass coverslips (11 mm. × 22 mm.) and the flasks incubated at 36° C. The medium was renewed daily for the first four or five days, the *p*H during this period showing diminutions from the 7·5 of the fresh medium to 6·6–6·8 within twenty-four hours. The fluid phase in the first twenty-four hours turned a chocolate-brown, due most likely to denaturation of hæmoglobin from red blood cells carried over with the ascitic fluid. Thereafter, the medium was renewed at weekly intervals for six weeks. Coverslips were withdrawn from random Porter flasks at the time of fluid renewal and stained by the May–Grünwald and Giemsa method[6].

Microscopic examination of the stained coverslips indicated that the ascites tumour cells maintained their usual appearance for at least the first week of culture. In the following weeks increasing numbers of cells showed progressive degeneration as manifested by increasing cytoplasmic vacuolation and karyoplasmic fragmentation. However, by the end of the sixth week there were still a considerable number of cells presenting a normal appearance. In this connexion, it should be mentioned that Hull[7], employing a subculture technique, has succeeded in serially culturing a line of ascites tumour cells for more than eight months. The frequency of blood cells and wandering cells was of the order of only a few per cent and these were readily distinguishable.

The utilization of cells morphologically, functionally, and potentially alike would permit a far more exact evaluation of host-cell reactions with, and responses to, specific viruses under conditions of culture. The Ehrlich ascites tumour cells being maximally dedifferentiated[8] do not manifest the protean ensemble of morphological forms so frequently observed with cells in culture, a phenomenon ascribed by Weiss[9] to 'modulations'. In addition to the advantage of uniform cells, which is ordinarily provided only by continuous cultures maintained over long periods of time, the absence of a fibrin clot affords the cells a maximum exposure to the viral particles in the fluid phase. Also, the ready manipulation and staining of the coverslips upon which the cultures grow permit a sequential study of cytomorphological development and change.

This investigation was aided by a fellowship from the National Foundation for Infantile Paralysis.

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Vaccination against Hæmorrhagic Septicæmia of Bovines

Hæmorrhagic septicæmia kills many thousands of cattle and buffaloes in Asia each year. Vaccination with conventional products such as formalin-killed cultures of *Pasteurella multocida* have not been considered an effective form of prophylaxis although practised for the past thirty years or so. The serological typing of strains of the causative organism and studies on its antigenic structure have not been pursued extensively in Asiatic countries in the past. In recent studies sponsored by the Food and Agriculture Organization of the United Nations, strains of *P. multocida* recovered from field cases of the disease in south-east Asia were typed by the mouse protection method of Roberts[1]; 14 Burmese, 3 Indian, 2 Pakistanian, 2 Malayan, 2 Siamese and one Indonesian strains were found to be type I. Only one other serotype was recovered from bovines—a single strain of type IV from Burma.

P. multocida type I is a small-capsule variety of pasteurella which, unlike the large-capsule varieties, is not decapsulated by bull testis hyaluronidase. During the first and second subcultivations after primary isolation, type I strains are agglutinable only by low dilutions of homologous antisera, but in subsequent subcultivations agglutinability is increased by up to a hundredfold without any obvious change in morphology. At the same time, agglutinability of cells in cetyl trimethyl ammonium bromide declines. These facts suggest that type I strains may have an antigen analogous to the 'Vi' of *Salmonella typhosa*. Cultures relatively inagglutinable in homologous antisera have been provisionally called 'phase I' cultures and are used for vaccine production. Simple formalin-killed bacterins made from 'phase I' cultures have not been highly successful as prophylactic agents, only 1 of 11 and 11 of 16 bovines having been protected against a 25,000 lethal dose challenge four weeks after inoculation. However, when an equivalent dose of 'phase I' cells, formalin-killed, was incorporated in a mineral oil–lanolin emulsion and injected intramuscularly in a dose of 2 ml. the results were greatly improved. In a series of small experiments in Burma and Siam a total of 36 of 39 cattle and buffaloes were protected against 25,000–200,000 lethal doses injected subcutaneously four to five weeks after inoculation with adjuvant 'phase I'

vaccine. One out of five cattle inoculated with adjuvant 'non-phase I' vaccine survived comparable challenge. Animals with naturally acquired immunity were detected and eliminated from the experiments by a serum agglutination test using 'phase I' cells as the agglutinating suspension. Every one of twenty control unvaccinated cattle and buffaloes used in these experiments succumbed to the challenge dose of live culture. Experiments are continuing on a larger scale to test the duration of immunity and its effectiveness under field conditions. Details of the experiments mentioned above are being reported in full elsewhere.

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Sodium : Potassium Ratio in the Hypophysis

It was observed in 1947 [1] that the thyroid gland of the mouse specifically accumulates intravenously injected uranin (sodium-fluoresceinate); large concentrations of sodium are known to be present in the thyroid colloid. Similarly, we observed the appearance of uranin upon intravenous injection of its 5 per cent solution in high amounts in the hypophysis of mice, particularly in the posterior lobe of this gland[2].

The affinity of elements of the 'extracellular' group in general for the pituitary is suggested by the specific accumulation of radioactive iodine in its posterior lobe[3,4]. It parallels the high molecular concentration of calcium and aluminium in the thyroid gland[5] and of electropositive organic bromine compounds in the pituitary[6].

Assuming a parallelism between the high sodium-levels and uranin accumulation, we determined by flame photometry the sodium and potassium content of the posterior and anterior lobes of the pituitary in large animals.

The organs were obtained at the slaughter house and placed in a deep-freeze box within 50–60 min. after death. We analysed glands from calf, cow, ox and steer; in the case of lambs' glands, the size of the glands available did not permit us to analyse the lobes separately. Weighed amounts of 0·8–1·5 gm. were heated to ash in a platinum crucible. The ash was taken up in a few drops of concentrated hydrochloric acid and again reduced to ash at red heat. The residue was then made up to 10 ml. with water and the appropriate dilutions were analysed in the flame photometer (apparatus of Process and Instrument Co., Brooklyn).

The moisture content, determined by drying at 105°, of the posterior lobe was, with a single exception, within the range of 71·5–75 per cent, the ash content 1·12–1·48 per cent. The corresponding figures for the anterior lobe were: moisture 76–81 per cent, ash 0·68–1·05 per cent.

The accompanying table summarizes the results, giving the concentration of the elements in milli-equivalent values/100 gm. of tissue and also the molar quotients K/Na. Except for the posterior lobes in Nos. 1 and 3, the anterior lobe in No. 5 and the whole gland in No. 9, there is a consistent prevalence of sodium over potassium.

The predominance of sodium, and possibly of the entire 'extracellular' group of elements, seems to be particularly pronounced in the steer. The lowest potassium values were shown in the anterior lobe of the calf. We believe that the prevalence of sodium is a characteristic feature of the hypophysis throughout the mammals.

Sodium and Potassium Concentrations in the Hypophysis

No.	Animal	Posterior lobe		K/Na	Anterior lobe		K/Na
		Milli-equivalents per 100 gm.			Milli-equivalents per 100 gm.		
		K	Na		K	Na	
1	Calf	5·34	3·49	1·53	1·18	1·22	0·96
2	,,	4·46	5·74	0·78	1·34	4·04	0·33
3	Cow	5·16	5·04	1·02	2·27	3·25	0·70
4	,,	5·10	5·70	0·89	3·87	4·18	0·93
5	Ox	4·55	5·05	0·90	6·80	5·10	1·35
6	Steer	5·66	7·55	0·75	4·44	5·12	0·87
7	,,	5·10	7·38	0·69	3·31	5·28	0·63
8	,,	4·94	6·07	0·81	2·78	4·82	0·58
9	Lamb (whole organ)	7·65	4·54	1·68			
10	,,	4·06	6·80	0·60			

Comparisons of potassium and sodium content of animal organs[7] show predominance of potassium in most of the internal organs and the highest values in the musculature and the erythrocytes. The lowest K/Na quotients, on the other hand, are shown by blood plasma, bone and skin. Like the thyroid, the pituitary gland belongs, according to our determinations, to this latter group of organs. The prevalence of sodium over potassium is shared in most cases by the posterior and anterior lobes.

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Diabetogenic Action of Pancreatic Glucagon

In previous experiments it has been shown that pancreatic glucagon, produced in the *A* cells of the pancreatic islets[1], significantly increases the blood-sugar-level and the urine glucose of intact rats, forcibly fed on a high carbohydrate diet; in these conditions glucagon also augmented the diabetogenic effect of pituitary somatotropic and corticotropic hormones as well as of cortisone. Combined treatment with glucagon and cortisone was the most effective in provoking a temporary diabetic condition[2].

We have now carried out experiments on intact, normally fed rats with either cortisone or glucagon alone and with combined treatment, in order to investigate further the possible role of glucagon in the disturbances of the carbohydrate metabolism.

Fifty-four male adult rats, weighing 118 ± 2·3 gm. at the start of the experiment, were fed on a synthetic diet containing 25 per cent proteins, 63 per cent

carbohydrates, 10 per cent lipins, 2 per cent McCollum salt mixture and supplements of vitamins and lipotropic factors; water was allowed *ad libitum*. The intake of food was kept constant, 15 gm. per 100 gm. of body-weight being allowed daily and regularly consumed. The animals were kept in metabolism cages and the urine collected daily.

The animals were divided into three groups: 14 rats were treated with cortisone acetate ('Cortone' Merck), 5 mgm. daily subcutaneously; 16 with glucagon 1 mgm. of protein daily intraperitoneally in two divided doses; and 24 with cortisone plus glucagon, respectively 5 and 1 mgm. daily. Impure glucagon was prepared from alkali-inactivated insulin, according to the method of Sutherland and co-workers[3]; an amorphous insulin, rich in this factor and kindly supplied by Dr. W. R. Kirtley, Eli Lilly and Co. (lot *ML* 509948), was used for its preparation. Our preparation, tested intravenously in rabbits and on liver slices *in vitro*, showed a high hyperglycæmic and glycogenolytic activity. The treatment lasted twenty days. Fifteen days after the beginning of treatment glucose and insulin tolerance tests were carried out on ten animals per group; in the morning 0·5 gm. of glucose per 100 gm. of body-weight was administered by stomach tube, and blood samples taken from the tail 0, 1, 2 and 3 hours after the tube feeding; in the afternoon 0·1 I.U. of insulin per 100 gm. of body-weight was injected subcutaneously and blood samples taken in the same way. At the end of the experiment the animals were weighed and killed by sudden decapitation; the pancreas was fixed in Susa fluid and studied morphologically in sections stained with the Gomori chrome-hæmatoxylin and phloxyn method[4].

During the experimental period the body-weight decreased $0·5 \pm 0·1$ gm. daily in cortisone group and $0·9 \pm 0·2$ gm. daily in cortisone plus glucagon group, whereas it increased $2·3 \pm 0·2$ daily in glucagon group. The occurrence of spontaneous infections in respiratory and digestive tracts was high in cortisone group (36 per cent) and was not evidently reduced by the simultaneous administration of glucagon (30 per cent); no infections were observed in glucagon group.

A dosable glycosuria was never observed in cortisone and glucagon groups, while the animals having combined treatment displayed constantly an appreciable glycosuria, beginning at the 7–9th day of treatment and gradually increasing in the following days up to 50 per cent. After stopping the treatment glycosuria promptly disappeared. The fasting blood sugar was 164 ± 18 mgm. per cent in the animals having combined treatment, while in cortisone and glucagon groups it was respectively 84 ± 8 and 105 ± 7 mgm. per cent.

The hourly changes of the blood sugar in the glucose tolerance tests are recorded graphically in the accompanying figure. From this it appears that the tolerance was practically normal in cortisone and glucagon groups, while in animals having combined treatment it was evidently lowered. As regards the insulin test, the combined treatment only resulted in some resistance to the insulin.

At the histological examination of the pancreatic islets, no striking regressive changes were demonstrable; a mild degree of hydropic degeneration was sometimes detectable in *B* cells of the animals having combined treatment. In all groups the *B* cells were hypertrophied and showed poorly granulated cytoplasm; mitotic figures were exceptionally seen. The *A*/*B* cells ratio was unchanged in cortisone group,

———, Control; – – –, glucagon; ……, cortisone; —·—·, glucagon and cortisone

while in the two other groups the *A* cells were decreased in number, especially in the smaller islets, and showed hypotrophic changes.

From the foregoing results it appears that impure glucagon in itself cannot be considered as a diabetogenic factor in the intact rat; however, it can potentiate the diabetogenic effect of other hormones, such as cortisone, thus determining a temporary diabetic condition.

It seems that in normal rats the hyperglycæmic effect of glucagon is easily controlled through an extra-secretion of insulin; on the contrary, in cortisone-treated animals, where a high storage of liver glycogen occurs, glucagon can release higher amounts of glucose in the blood stream, thus inducing a relative insulin deficiency. Nevertheless, there are other possibilities for explaining our results: for example, an inhibitory effect either of glucagon or of cortisone on the peripheral utilization of glucose or a direct inhibitory effect on the insulin secretion might be the mechanisms here involved. At present, our knowledge of the physiological activities of glucagon is too slight for giving a complete explanation of the observations.

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Abnormal Accumulation of 3-Hydroxykynurenine in the Mutant 'Aka-Aka' of Silkworm

Recently, Inagami[1] obtained (isolated) a mutant of *Bombyx mori*, proved that it is based upon a single recessive gene and called it 'Aka-Aka' (*rb*), which means red colour in Japanese, for the skin of the mature larva is red and its body fluid turns fairly red when exposed to air in contrast with the blackening of the normal type.

In order to investigate the mechanism of this red colouring we dialysed the body fluid gathered from several larvæ of this mutant against diluted acetic acid, and the external dialysate, which showed a strong ultra-violet absorption band and an intensive diazo reaction (red), was concentrated under reduced pressure in an atmosphere of hydrogen. The resultant syrup was chromatographed on No. 50 Tōyō filter paper (40 cm. × 40 cm.) using water – acetic acid – butanol (ascending method), and the chromatogram was observed under ultra-violet light; only one main fluorescent band was detected between R_F values of 0·30 and 0·38. This band was cut out and, after elution with water, we carried out paper-chromatography, colour tests and ultra-violet absorption spectrography with the elute. As indicated below, the substance concerned was shown to be 3-hydroxykynurenine. It gave a green fluorescence, the ninhydrin reaction, a strong diazo reaction (brownish-red, turning slowly to brown), Ehrlich's reaction with aldehyde (pink) and a ferric chloride colour test (brown); R_F in butanol – acetic acid, 0·39; R_F in 70 per cent propanol, 0·31; R_F in benzene–butanol–methanol–water (1 : 1 : 2 : 1), 0·38; absorption maxima (*p*H 3·0) 270 and 370 mμ. The same values as above were obtained with an authentic sample of 3-hydroxykynurenine.

In accordance with the strong diazo reaction of the external dialysate (see above), the estimated value for 3-hydroxykynurenine in the body fluid, which was determined by another method[1], was strikingly high, amounting to 15 ~ 20 times as much as that in the White-2 mutant or the normal type.

The abnormal colouring of the 'Aka-Aka' mutant is presumably due to extraordinary accumulation of 3-hydroxykynurenine, for Inagami[1] could induce the red-colouring by addition of this substance to the dopa–tyrosinase system, differing from the case without addition of 3-hydroxykynurenine (in this case, as is commonly known, the reaction mixture turns black).

We thank Prof. T. Sakan for a gift of 3-hydroxykynurenine.

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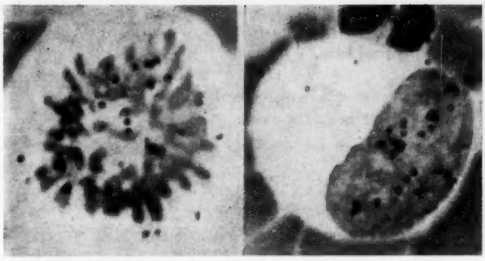
Detection of Adenine Carbon-14 in Deoxyribonucleic Acid by Autoradiography

The standard procedure for detecting phosphorus-32 in deoxyribonucleic acid by autoradiography is to hydrolyse the smears or sections in *N* HCl at 60° C. for 6–10 minutes. The acid hydrolysis removes RNA and most of the non-DNA phosphates.

Adenine carbon-14 administered *in vivo* or *in vitro* will be taken up by both nucleic acids. Since, however, the usual biochemical procedure to isolate the purine bases from the nucleic acid solutions is



Adenine carbon-14 in deoxyribonucleic acid. Human bone-marrow cells cultured *in vitro* for 24 hr. in 0·5 μc./ml. adenine-8-^{14}C. Smears fixed in alcohol and hydrolysed in *N* hydrochloric acid, 60° C., 6 min. Stained autoradiographs. (× 1,400)

acid hydrolysis, the histochemical separation of RNA from DNA is usually performed by ribonuclease.

Current work on the nucleic acid metabolism of human bone marrow cells *in vitro* necessitated the use of adenine-8-carbon-14. Since the RNA turnover was found to be higher in the nucleus than in the cytoplasm, the autoradiograph above the nucleus cannot give even approximate information on the rate of DNA synthesis unless RNA is removed from the cells.

The preparation of ribonuclease is somewhat cumbersome and batches may vary in activity, mainly due to the amount of impurity present in the preparation. The enzyme is sensitive to *p*H, which also has to be controlled, during incubation of the enzyme, with smears or sections.

In order to find a simple and easily standardized procedure it was decided to investigate the action of acid hydrolysis on DNA adenine in smears. Although the literature described the isolation of purine bases from nucleic acid solutions by acid hydrolysis, no experimental evidence was found that the same effect will occur in alcohol-fixed smears on brief hydrolysis.

Human bone marrow cells were cultured *in vitro* in 0·5 μc./ml. adenine-8-carbon-14 for 12–24 hours. The smears were fixed in 95 per cent alcohol and one batch was treated with ribonuclease (2 mgm./ml. for 2 hr. at 37° C.), the other with *N* HCl at 60° C. for 6–10 min. The slides were coated, using stripping film, and stained autoradiographs were made, as described elsewhere[1]. It was found that in the smears six minutes hydrolysis gives identical pictures to those of the ribonuclease. The grain counting over the nuclei of the acid-hydrolysed or ribonuclease-treated cells indicates an uptake of the order of 10–15 × 10^6 carbon-14 atoms in twenty-four hours. Since the total number of DNA adenine + guanine molecules per nucleus is of the order of 0·85 × 10^{10} this implies a very high degree of labelling of the DNA. More than seven minutes hydrolysis tends to decrease the strength of the autoradiographs; presumably some purine bases are removed from the DNA by prolonged hydrolysis. The application of deoxyribonuclease prior to acid hydrolysis renders the smears completely free from carbon-14 activity.

The photomicrographs illustrate the pictures thus obtained with acid hydrolysis. It is a procedure easy to standardize and has been found a simple method for the autoradiographic determination of DNA adenine.

This work is part of an investigation carried out with a grant from the British Empire Cancer Campaign. Grateful acknowledgment is made to Dr. S. R. Pelc, of the Radiopathological Research Unit

of the Medical Research Council, Hammersmith Hospital, for the samples of ribonuclease and deoxyribonuclease.

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Presumed Antitubercular Activity of 4-Amino-6-Hydroxy-*iso*-Phthalic Acid

Among the numerous compounds obtained by modifying the chemical molecular structure of *para*-amino-salicylic acid, our attention has been directed to 4-amino-6-hydroxy-*iso*-phthalic acid[1], especially concerning the discordant opinions in respect of its antitubercular activity. In fact, while Bavin *et al.*[2] have found an activity corresponding to that of the para-amino-salicylic acid, according to Beyerman and Alberda[1] the compound should be 2–5 times less active than *para*-amino-salicylic acid.

Investigators[1] have generally obtained this compound from *m*-aminophenol by means of a Kolbe reaction. In this reaction the principal product formed is *para*-amino-salicylic acid, while the 4-amino-6-hydroxy-*iso*-phthalic acid has to be isolated as a side-product.

Recently, Beyerman and Wielaert[3] have described a synthesis with 4,6-dinitro-*m*-xylene as starting material, and have found the same bacteriological activity as before.

We have synthesized this compound by another route with the view of examining these discrepancies.

For this purpose we nitrated the 1,2,4-xylidine with concentrated sulphuric acid and fuming nitric acid to 4-amino-6-nitro-*m*-xylene (m.p. 123°)[4], then the NH_2-group was substituted by diazotation by an OH-group which was transformed into the methyl-ether by suspending the solid sodium compound in xylene and by reacting with dimethylsulphate (yield 63 per cent). The two CH_3-groups were oxidized with $KMnO_4$ in a current of carbon dioxide (yield 50 per cent). By etherifying, Maltese[5] has obtained a yield of 25 per cent only, and by oxidizing with $KMnO_4$ but without carbon dioxide he obtained a mixture of mono- and di-carbonic acids which was scarcely separable. The splitting of the ethereal bond has been worked out with hydrogen bromide in acetic acid (glacial) (yield 63 per cent), m.p. 265° (crystallized from water). Calc. for $C_9H_9NO_7$: C, 42·30; H, 2·22. Found: C, 42·47; H, 2·14.

Successively, the nitro compound has been reduced to an amine with platinic oxide in alcohol; m.p. 212° (crystallized from diluted alcohol). Calc. for $C_9H_7NO_5$: C, 48·73; H, 3·58; N, 7·10. Found: C, 48·91; H, 3·22; N, 7·16.

For identification, we have transformed the compound into dimethyl 4,6-dimethoxy-*iso*-phthalic acid, as has already been done by Beyerman and Alberda[1]. This compound had a melting point of 147–148° C., in accordance with the literature[6].

With the compound so prepared, inhibitory concentrations have been worked out in Youmans's medium with *M. tuberculosis*, strain $H_{37}Rv$, by inoculating 0·01 mgm. for 1 ml. of medium.

The results, read after fifteen days of incubation at 37°, have shown that for the *para*-amino-salicylic acid the minimal quantity to inhibit the growth is 0·1 mgm./100 ml., while for 4-amino-6-hydroxy-*iso*-phthalic acid it is 5 mgm./100 ml.

Therefore, the compound has been found to be much less active than described in the literature, and for this reason we suppose that other authors have worked with a product which was insufficiently pure and which contained other more active compounds.

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Methyl Proline in Young Apple Fruits

It was recently suggested that a 'new' amino-acid isolated from the apple fruit was a methyl proline[1]. This acid (called D_1 in the original communication) has now been compared with an authentic specimen of γ-methyl proline kindly supplied by Prof. F. C. Steward, of Cornell University. The positions occupied by these two acids on two-dimensional chromatograms (phenol ammonia–butanol–acetic acid–water) were found to be identical. Mr. J. K. Pollard in Prof. Steward's laboratory has also found the two compounds to superimpose on collidine–lutidine: phenol chromatograms. The two compounds (D_1 and γ-methyl proline) give identical colour reactions on paper chromatograms with ninhydrin (a yellow-orange colour) and with isatin (a pure blue colour developing at the same rate with both acids). Not more than ~ 17 mgm. of D_1 were obtained from 70 kgm. of young Worcester Pearmain apples, and elementary analysis on a sample containing traces of inorganic salt gave the following: C, 53·6 per cent; H, 8·17 per cent; N, 9·7 per cent. Assuming this indicates a C_6 compound with an empirical formula of $C_6H_{11}O_2N$, and correcting the analyses for ash gives: C, 55·8; H, 8·5; N, 10·1; methyl proline requires: C, 55·8; H, 8·5; N, 10·8 per cent.

It has already been shown that this acid is not the isomeric piperidine-2-carboxylic acid[1]. In the Cornell laboratory, using washed and buffered papers, authentic γ-methyl proline was readily separable from pipecolic acid in butanol acetic chromatograms (γ-methyl proline, $R_F = 0{\cdot}259$; pipecolic acid, $R_F = 0{\cdot}214$). In the Ditton Laboratory, D_1 was not separable from pipecolic acid in butanol–acetic chromatograms. Therefore, this evidence alone is inconclusive. (It was unfortunately not possible to compare D_1 with the γ-methyl proline under the Cornell conditions.) The possibility is thus not ruled out that the material D_1 is any one of the possible methyl prolines. The constitution suggested by Grassman and von Arnim[2] for the blue-coloured compound formed between proline and isatin does not help here since β- and γ-positions in the pyrrolidine rings are not involved.

Circumstances make it unlikely that further quantities of the acid will be obtained from the apple in this Laboratory in the near future; the object of this communication is to stimulate the search for methyl proline in other plant material.

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A Histochemical Property of the Argentaffin (Kulschitsky) Cells

Baker[1] introduced in 1946 a carefully standardized technique, developed from the Smith–Dietrich test, for the detection of lipines. In a later communication[2] he claimed that this modification (the acid–hæmatein test), controlled by his pyridine-extraction test, allows histochemical recognition of phospholipines. This was confirmed by Cain[3] while working in Baker's laboratory.

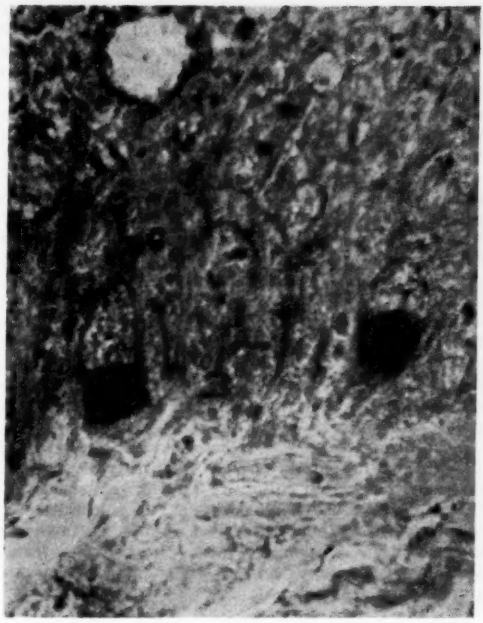
Casselman[4] applied this technique to certain synthetic enantiomeric α-phosphatidic acids, α-phospholipines, and related compounds, and to highly purified, natural lipine fractions, as well as to an additional 123 other substances: only phospholipines and certain phosphatidic acids gave positive results. His findings, while confirming Baker's claim, also suggested that "the entire phospholipine molecule may not be essential because some phosphatidic acids also give true positive reactions" (that is, positive in the acid–hæmatein test and negative in the pyridine-extraction test).

In his earlier communication, Baker observed that the Paneth cell granules in mouse intestine gave a positive though "rather weak" reaction which was negative in pyridine-extracted tissue.

In the intestine of two species (man and guinea pig) I have found that the argentaffin cells give a positive reaction with the acid–hæmatein test and a negative one in the pyridine-extraction test. As is well known, these cells in man are packed with infra-nuclear granules, which reduce solutions of ammoniacal silver nitrate with resulting deposition of silver on them[5]. The accompanying illustration shows such cells in a human appendix stained by Baker's acid–hæmatein method. (They are unstained in the pyridine-extraction test.)

This test has also been applied to human post-mortem material fixed 1¾ hr. after death, with equally successful results. The argentaffin cells in guinea pig intestine likewise give clear-cut positive results.

Sections of gelatin-embedded, formalin-fixed tissue from a surgically removed argentaffin (carcinoid) tumour of the ileum in an elderly male were immersed in cold 5 per cent potassium dichromate–1 per cent calcium chloride solution for eighteen hours, followed by further treatment with this mixture at 60° C. for twenty-five hours, and then treated as directed in Baker's test. Many of the tumour cells grouped in acini about a central lumen, and especially such acini just beneath the stretched, overlying intestinal mucosa showed the characteristic fine infra-nuclear granules reacting positively.



Appendix from a woman aged twenty showing two argentaffin cells stained by Baker's acid–hæmatein method. (× 1,000)

Sections of this tumour stained by Gomori's[6] hexamine–silver nitrate method showed that these granules in morphologically similar cells gave the characteristic argentaffin reaction. Although in this latter case the test was not performed strictly according to Baker's specifications, in that sections were cut from gelatin blocks of tissue fixed for several weeks instead of six hours in formal–calcium before chroming, it affords strong presumptive evidence that the characteristic alkaline silver-reducing granules very often seen in the cells of argentaffin tumours also contain a phospholipine.

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Photoelectric Spectrophotometry of Planetary Nebulæ

The electron temperature of a planetary nebula can be determined from the relative intensities of the N_1 and N_2 lines of [OIII] at λλ5,007, 4,959, and the 'auroral' type transition at λ4,363, provided the target areas for collisional excitation are known[1].

The N_1 and N_2 radiations are usually very much stronger than λ4,363. The photographic measurement of the intensity of λ4,363 with respect to $H\gamma$ and $H\beta$ is not difficult; but photographic photometry is not

well suited to the measurement of the ratio, R, of the intensity of $N_1 + N_2$ to that of $H\beta$. This is because the ratio is often large, the sensitivity of the emulsion is changing rapidly in the spectral region involved, and the nebular images in the light of hydrogen and [OIII] often show structural differences. Accordingly, a check upon the photographic determinations of this ratio is very much to be desired.

Between May and August 1953 we obtained some photoelectric measures of the ratio R in a number of planetary nebulæ using the 24-36-in. Schmidt telescope of the Warner and Swasey Observatory. The objective prism provided a spectral image of each nebula at the focus (97″/mm. and 275 A./mm. at $H\beta$). An *RCA* type 1*P*21 photomultiplier tube with associated equipment[2] measured directly the total light intensity in the various spectral images. Details of the procedure for eliminating the effects of overlapping images, spectral sensitivity of the cell, atmospheric extinction, and the stellar continuum will be published elsewhere.

For the five planetaries listed in the first column of Table 1 numerical values for the ratio, R, are given in the second column. The probable errors of R are listed in the third column, and the number of runs over the spectrum of the nebula, n, are given in the fourth. The more precise photoelectric results confirm the accuracy of Aller's photographic measures[3] given in the last column.

Table 1

NGC	R photoelectric	Probable error	n	R photographic
6,543	8·07	0·14	10	8·1
6,826	9·8	0·2	3	10·7
6,572	15·75	0·13	11	12·9
7,027	20		1	18·7
7,662	20·0	1·4	4	21·2

The photoelectric observations provide additional information which is very difficult to obtain by other methods, namely, the intensity of the emission lines in terms of the energy in the continuum of the central star. Results for two planetaries are given in Table 2. For each, the number in the second column is the intensity of N_1 and N_2 combined in terms of the energy per angstrom in the stellar continuum at λ5,007.

Table 2

NGC	$N_1 + N_2$/cont.	Probable error	n
6,826	2,300	140	3
7,662	1,500	60	4

We wish to thank Mr. L. H. Aller for directing our attention to this problem from the observational point of view.

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Fermi's Thermodynamic Theory of the Production of Pions

Fermi's[1] statistical thermodynamic theory of the generation of pions in collisions of high-energy nucleons has stimulated considerable discussion of the problem. The theory is in reasonably good agreement with observation; but the theory is not free, as Fermi himself and others[2] have pointed out, from conceptional difficulties. However, the purpose of the present note is to show that in the usual derivation[1] for the number of pions produced on Fermi's theory, the contribution of the pions in the lowest energy-state is not adequately taken into account. In fact, because of the Lorentz-contraction of the volume (in which pions are produced) the usual estimate of the total number of pions produced has an appreciable error. In the absence of the Lorentz-contraction the error would be entirely negligible.

Let us consider the sum (in the usual notation):

$$N_1 = \sum_i \frac{1}{e^{\beta\epsilon_i} - 1}, \quad \beta = 1/kT. \tag{1}$$

Let N stand for the integral

$$N = \frac{4\pi g\Omega}{(2\pi ch)^3} \int_0^\infty \frac{t^2 dt}{e^{\beta t} - 1} = \frac{4\pi g\Omega}{(2\pi c\cdot)^3}\, 2!\, \frac{\zeta(3)}{\beta^3}, \tag{2}$$

where Ω is the volume of the assembly and g the weight factor for the pions ($g = 3$).

If we write

$$N_1 = N + N_0, \tag{3}$$

then it follows that

$$N_0 = \alpha g k T/\mu c^2, \tag{4}$$

where α is a numerical factor of the order unity. If W is the total energy of the colliding nucleons in the co-ordinate system (called C-system) in which the total momentum is zero, we have, on substituting for (kT) in terms of W:

$$\frac{N_0}{N} = \frac{\alpha[9\pi\zeta(4)\,]^{1/2}}{2\zeta(3)} \left(\frac{g\mu}{M}\right)^{1/2} \frac{1}{(\gamma f)^{1/2}}, \tag{5}$$

where M is nucleon rest mass, $\gamma = W/Mc^2$, and f is defined by

$$f = \Omega/\Omega_0, \ \Omega_0 = \frac{4\pi}{3}(\hbar/\mu c)^3. \tag{6}$$

When $f \sim 1$, $\frac{N_0}{N} \to 0$ for large γ. However, in Fermi's theory the volume available in the C-system for production of pions is not Ω_0, but the Lorentz-contracted volume $2\Omega_0/\gamma$. Hence, we have

$$\frac{N_0}{N} = \alpha \frac{[9\pi\zeta(4)\,]^{1/2}}{2\zeta(3)} \left(\frac{g\mu}{2M}\right)^{1/2} \sim 0{\cdot}54 \text{ (for } \alpha = \tfrac{1}{2}). \tag{7}$$

Thus the number N_0 is of the same order as N, and hence Fermi's expression (equation (2)) seriously underestimates the total number of pions produced. In the laboratory system the N_0 pions will form a narrow jet moving along the direction of the incident nucleon, each pion having an energy $\gamma\mu c^2/2$.

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Thermoelectric Power of Cold-worked Copper at Low Temperature

THE influence of cold-working on the thermoelectric power has been measured by a number of workers[1]. At room temperature we carried out measurements on copper and silver wires. For a certain amount of cold-working it is found that the relative increase of the absolute thermoelectric power is greater than the relative increase of the resistivity. These results do not agree with the theoretical prediction of T. Hirone and K. Adachi[2].

So far as we know, no measurements have been carried out at low temperatures.

We measured the thermoelectric force between a wire, drawn at room temperature, and an annealed wire as a function of the temperature of the hot junction. The cold junction was always kept at liquid air temperature (83° K.) (Fig. 1).

Each curve reaches a minimum at a certain temperature which is dependent on the amount of cold-working. At the minimum the thermoelectric power (in 10^{-8} V. per deg. C.) is zero; it is positive above but negative below the corresponding temperature. So the absolute thermoelectric power increases above and decreases below the temperature mentioned.

Fig. 2 shows the temperature of the minimum, shown in Fig. 1, as a function of the percentage reduction of the area of the wire. In the same temperature-range we found cold-worked silver wires always had a positive thermoelectric power relative to annealed material.

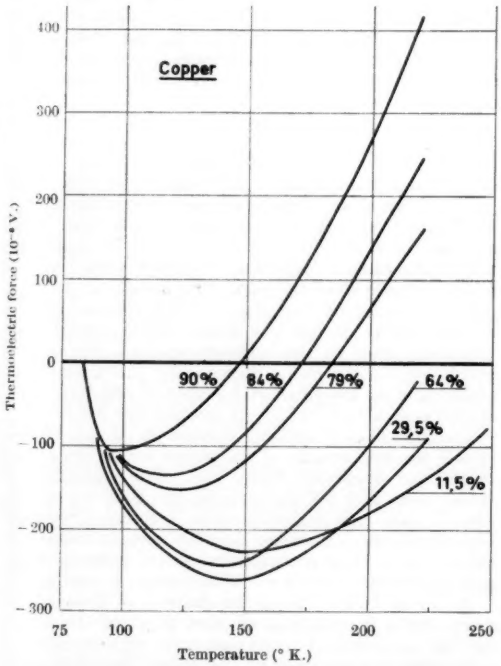

Fig. 1. The thermoelectric force plotted against the temperature of the hot junction for various percentage reductions by drawing. The cold junction is continually kept at 83° K. The thermoelectric force is always measured with respect to the same annealed copper wire

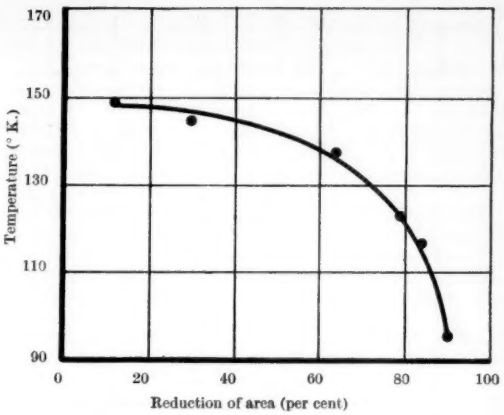

Fig. 2. The temperature of the minimum of a curve of Fig. 1 plotted against the corresponding percentage reduction of the area of the wire.

As usual we call a metal A positive with respect to a metal B if at the cold-junction the (positive) current flows from A to B. So far as we know the results for copper do not agree with any theory on the thermoelectric power.

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Nov. 11.

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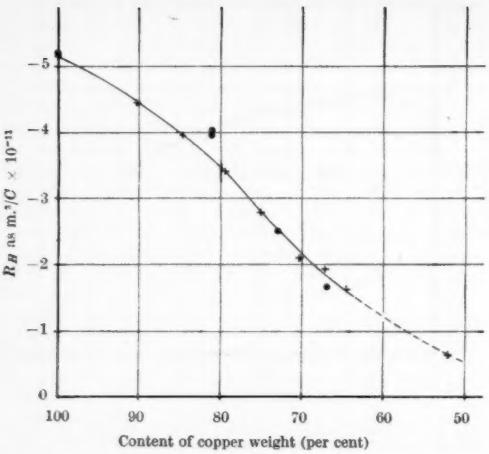
Measurement of the Hall Coefficient of α- and β-Brass

THE measurements described herewith were undertaken in order to find out whether any pronounced change in the Hall coefficient takes place when passing from α- to β-brass.

The well-known method employing d.c. was used, and the specimens were cut from thin sheets of brass. Small blocks of the materials were produced from thin copper wire and small pieces of zinc by melting in vacuum in a quartz tube, and the sheets were then produced by rolling from these small blocks. (The specimen of 52 per cent copper was milled down from a cast block.) The rolling was carried out at room temperature; but due to work-hardening after a number of operations, it was found necessary to anneal the work once by heating in an inert atmosphere (nitrogen). The specimens were then cut out in rectangular pieces about 48 mm. by 17 mm. The thickness, measured directly, varied from $0{\cdot}0778 \pm 0{\cdot}0004$ mm. to $0{\cdot}156 \pm 0{\cdot}0005$ mm. The d.c. was applied to the specimens through two circular contacts (2 mm. diam.) placed symmetrically with a distance between centres of 40 mm. To exclude errors due to a fixed current direction, the polarity was reversed now and then.

A correction[1] for the short-circuiting of the Hall field by the contacts for the primary current has



Crosses: Present measurements; lengths of vertical and horizontal branches of the crosses indicate the standard deviations. ●, measurements by E. H. Hall

been introduced in the evaluation of the Hall coefficient.

The magnetic field was provided by an electromagnet and the field-strength was found to vary by not more than 0·3 per cent over the area of the sample. The alteration in the Hall potential, brought about by reversing this magnetic field while the current was kept constant, was measured by means of a highly sensitive galvanometer. A potentiometer was connected to two points (with a distance between them of about 4 mm.) of one of the long edges of the specimen. The galvanometer was connected to the slide and to a point on the other edge of the sample just opposite the potentiometer. The slide was then moved until no potential difference appeared by reversal of the current in absence of the magnetic field[2]. To minimize thermoelectric forces in this arrangement, all connecting wires as well as the potentiometer wire were taken from the same length of copper wire.

The results of the investigation are plotted in the accompanying diagram, showing the Hall coefficient as a function of the content of copper in the brass. Each point is the result of forty measurements made at 4–8 different d.c. currents (up to 27 amp.), but all with the same magnetic induction (0·646 V./m.² = 6,460 gauss), and the standard deviations are indicated in the diagram. Four points from measurements made by E. H. Hall in 1885[3] are also plotted. The composition of the brass was determined by the weight of copper and zinc before melting them together. On account of the annealing the homogeneity of the specimens was high and was found to be satisfactory by chemical analysis of different parts of the brass samples. Thanks are due to Mr. J. Rathlev, for making the analyses.

Down to about 65 per cent copper the alloy can be considered to be pure α-brass. At 52 per cent copper it can be considered to be pure β-brass. It appears that the sign of the Hall coefficient is unaffected by the change from α- to β-brass, in opposition to what might be expected from the theory of H. Jones[4] for the phase boundaries in binary alloys.

I wish to thank Prof. T. Bjerge and Prof. H. Højgaard Jensen for their interest in this work and for much valuable advice.

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Direct-Current Corona

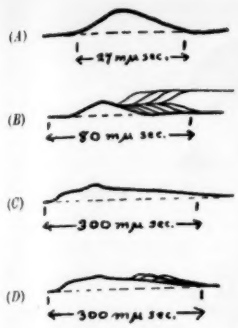
It has previously been reported that the corona in a point-plane gap to which is applied a steady d.c. potential (positive point, negative plane) consists of a series of short-duration pulses[1,2], and this had also been observed by me. The results of English[1], who used a photomultiplier to study the light emitted by the corona, show that this light is emitted in the form of pulses of total duration of approximately 6×10^{-8} sec. with "a plateau which gives the impression of two overlapping peaks".

Recently, I have studied the corona for the above-mentioned experimental conditions, using an oscillograph and amplifiers which enable random pulses of a few tens of micro-amperes amplitude and of duration of the order of 10 mμsec. to be displayed. The current flowing in the gap due to the corona was investigated by inserting a resistor in series with the earthy point and displaying the volt-drop produced across this resistor, after amplification, on the oscillograph. Since the capacitance of the pointed electrode may be made very much smaller than that of the plane electrode, the time-constant associated with the measuring equipment may, by this means, be reduced to a minimum.

For a gap-length of approximately 3 cm. between a platinum wire of 0·005 cm. diameter and an aluminium plane in air at atmospheric pressure, 'noise' is observed from about 9 or 10 kV. upwards. This noise is less than 10 μamp. mean amplitude and is similar to that seen, for example, on a normal linear sweep. It is unidirectional, increases in amplitude with increasing voltage and vanishes with removal of the voltage from the gap. The measurement by a micro-ammeter of the d.c. current flowing in the pointed electrode gives a value which agrees with the mean level of the noise as seen on the oscillograph, within the limits imposed by the difficulty of calibrating an amplifier with a gain of approximately 30,000 and a band-width of around 100 Mc./sec.

Increase of the applied voltage to about 15 kV. causes the appearance of the pulses which are shown in the accompanying figure (*A*). The amplitude of these pulses is 2–300 μamp. peak and their repetition-rate is low, but increases with increasing voltage. Due to the short duration and low repetition-rates of these pulses, their contribution to the current in the gap, as measured by a micro-ammeter, is negligible.

At about 19 kV., the pulse shape is as shown in *B*, from which it will be seen that most of the pulses are the same as in *A*; but that a few of them develop a 'plateau' on the back of the pulse. In some cases, this plateau is ended by a fall to zero, but in others the current rises until the amplifiers are saturated. The duration of the plateau is variable.



Reduction of the amplifier gain enables the pulse shape of this rising current to be observed, and this is shown in *C*. The pulses have a peak amplitude of approximately 20 m.amp. and a duration of approximately 0·3 μsec. These pulses are therefore similar in duration to that of the impulse corona[2-5], although the duration of the front of the d.c. corona pulses appears to be larger than that of the impulse corona.

A further increase of the applied voltage causes secondary pulses to occur on the backs of some of the pulses shown in *C*, and the resultant pulse shape is shown in *D*. At this voltage, occasional spark breakdown may occur.

Visual observation of the gap at the stage when the pulses shown in *C* are present shows that luminosity appears to extend across the whole gap, being confined to a channel of small diameter near the point and spreading out in a fan shape nearer the plane, and being enhanced by contact with this electrode.

The velocity of propagation of the luminosity has been measured with the aid of a photomultiplier technique[6], and I find that this luminosity moves from the point to the plane at a constant velocity of approximately 4×10^7 cm./sec. Within the limited range available for investigation to date, this velocity is independent of the gap length. The amount of light emitted by the luminosity as it crosses the gap remains approximately constant, and the extension of the luminosity in the direction of motion, at any instant, appears to be small compared with the gap length.

The small 'bump' on the top of the wave-form shown in *C* appears to coincide with the arrival of the luminosity at the plane.

The duration of the pulses shown in *C* appears to be affected by a change in either the gas pressure or the composition of the gas—a mixture of nitrogen and oxygen.

It should be pointed out that the above phenomena occur without the introduction of any external irradiation, and may therefore be considered to be self-sustaining.

The interpretation of the phenomena described is not yet clear, except possibly in the case of the 'noise'. This cannot be considered as a 'shot-effect' since a current of 3 amp. is required to give an r.m.s. shot-noise current of 10 μamp. for a band-width of 100 Mc./sec. It would therefore appear that the 'noise' is caused by electron avalanches, individual avalanches being subject to statistical variations in the number of component electrons and therefore in the current produced, and the number of avalanches at any time also being statistically variable.

The amplitudes, durations and repetition-rates of the pulses shown above are such that the measurement of the current in the gap by a d.c. meter is unlikely to give an indication of the existence of the pulses, and therefore any analysis of the breakdown mechanism made solely from such a measurement will probably be false.

Acknowledgment is made to Prof. W. J. John, in whose laboratories this work was carried out, to the I.C.I. Research Committee for the award of a fellowship, and to the London University Grants Committee for a grant for the construction of the apparatus.

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Abnormalities of Stored Seed

Seeds of a variety of plants have been stored in unsealed air, sealed air, and carbon dioxide. All have been kept at laboratory temperature for five years. In all cases unsealed seed has deteriorated more rapidly than sealed seed. Furthermore, CO_2-sealed seed has generally given better germination than seeds stored in sealed air. In two varieties of lettuce the original yield of mature plants from sealed seed has been maintained while the plants grown from unsealed seed have a diminished yield (Table 1). Lettuce and onion seeds have been selected for a cytological study because these showed marked differences in deterioration and were suitable material technically.

Chromosomal aberrations in *Crepis* and *Allium* raised from old seed have been reported[1,2]. We have likewise found gross abnormalities in old lettuce and onion seed; but as with germination, these effects are influenced by the type of storage (see Table 1).

Primary roots were fixed approximately one day after germination, that is, at the end of the period of elongation and at the time that the cells were undergoing their first mitoses. The total anaphase cells were scored from at least five roots from each of the treatments to assess chromosome breakage and mitotic activity. The results are summarized in Figs. 1 and 2.

Examination of metaphase cells in lettuce has revealed that all the breakage is of the chromosome type, that is, it is occurring in the early resting stage before the time of chromosome reproduction, giving

Table 1. Percentage Germination and Yield

		Lettuce variety					Onion
		White Heart (cos)	May Queen (cabbage)	Continuity (cabbage)	Arctic King (cabbage)	Black Seeded Bath (cos)	Bedfordshire Champion
Storage	Unsealed	24 (4)	0	66 (8)	11	20 (3)	2
(5-year-old seed)	Sealed air	86 (17)	12	91 (8)	65	92 (19)	11
	Sealed CO_2	95 (18)	66	96 (9)	56	93 (17)	33
(1-year-old seed)	Control	97	90	91	94	89	76

Figures in brackets are mean yields of mature plants in ounces

dicentrics but no chromatid interchanges. At anaphase the resulting bridges and fragments are readily observed (Fig. 3).

The lettuce varieties tested show a differing effect of the treatments, and this difference is reflected in breakage, mitotic activity and germination. Although varietal differences occur, the general trend shows a sharp decrease in chromosome abnormalities at high germination values and a corresponding rise in mitotic activity. The onion results, however, differ markedly from the lettuce in revealing a low incidence of breakage at all levels of germination. This shows that in the case of onion, at least, a decrease in germination is not necessarily determined or followed by an increase in the frequency of abnormal cells.

It has been stated that decreased germination and increased chromosome breakage are parallel effects of ageing[3]. The present results clearly show that ageing alone is not responsible for these changes as storage conditions can overcome the effects of age.

Three varieties of lettuce under discussion were grown to maturity in 1953. The diminished yield in White Heart and Black Seeded Bath grown from unsealed seed (as shown in Table 1) was probably due to a reduction in root formation consequent upon the high proportion of abnormal cells present in the primary root. Where the proportion of abnormal cells is low they can be readily replaced by active division of normal cells, as has probably occurred in the variety Continuity.

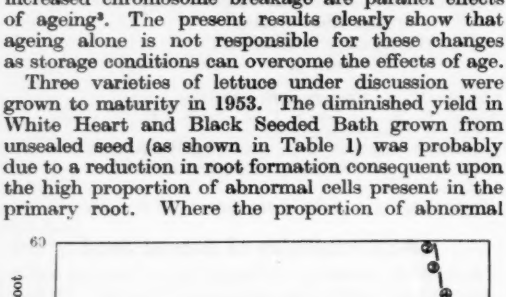

Fig. 1. Relationship between germination and mean number of anaphases per primary root. (The latter used as an index of mitotic activity.) Lettuce varieties: White Heart, May Queen, Continuity, Arctic King and Black Seeded Bath numbered 1–5 respectively. Onion 6. Storage conditions designated as follows: *a*, unsealed; *b*, sealed air; *c*, CO_2-sealed; ringed figures are controls

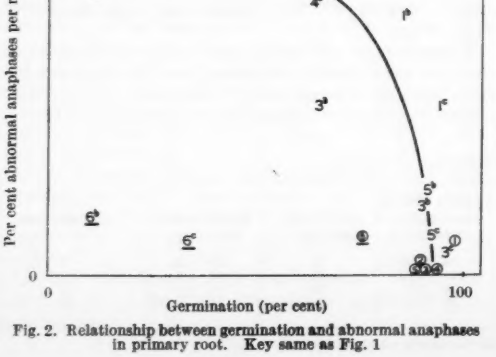

Fig. 2. Relationship between germination and abnormal anaphases in primary root. Key same as Fig. 1

Fig. 3. Abnormal anaphase in a primary root cell of White Heart lettuce 24 hr. after germination of 5-year-old seed. Shows criss-cross separation of a dicentric chromosome and two pairs of acentric chromatids. Feulgen squash preparation. (× 2,800)

Each of the three groups of plants of Black Seeded Bath grown from sealed and unsealed seed was fertile and produced viable seed. When sown after a short dormancy period each batch of seeds underwent normal germination and the primary roots showed normal mitotic activity with no chromosome abnormality. The gross rearrangements in the parental seedlings were not transmitted to the next generation, but small viable rearrangements may have been perpetuated.

These results show that gaseous exchange plays a large part in the metabolic processes of the resting seed and, in the case of sealed air and carbon dioxide, has counteracted to some extent the effects of age. The effects of ageing upon seeds must, however, be recognized as complex, and the production of cytological abnormalities to be a consequence rather than the initial cause of seed deterioration.

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Time of Death of Sex-linked Lethals of Different Origins in *Drosophila melanogaster*

Previously it had been found that the great majority of ultra-violet-induced lethal mutations involving no detectable chromosome changes cause the death of the individual carrying the mutation shortly before or after emergence of the larva from the egg case, or shortly before or after the transformation of the larva into the pupa, while a few caused death just before or after eclosion from the pupa case[1]. As an extension of this study it was planned to examine the immature stages of lethals of other origins in order to determine the times when they exerted their deleterious effects.

	Embryonic stages			Larval instars			Pupal stages			Totals
	Early	Middle	Late	1st	2nd	3rd	Early	Middle	Late	
1 Spontaneous lethals	0	0	1	13	0	9	8	0	4	35
2 X-ray-induced lethals	0	0	1	20	0	4	8	0	6	39
3 Ultra-violet-induced lethals (ref. 1)	0	0	7	27	0	9	9	0	3	55

Two groups of lethals were investigated:

(1) Sex-linked lethals which had arisen spontaneously in the female.

(2) Sex-linked lethals which had been induced by irradiation of mature spermatozoa with an X-ray dose of 700 r.

Methods for collecting and examining the immature stages of the lethal-bearing individuals have been described elsewhere[1].

The distribution of lethality is given in the accompanying table.

Two third-instar lethals have been found in the spontaneous group which exhibit melanotic tumours at the time of death, and these are being further investigated.

The clustering of mortality is similar to that found previously for the ultra-violet-induced lethals. Hadorn has found a somewhat similar distribution of the time of death of fifty-nine non-allelic autosomal lethal mutations which arose spontaneously or had been induced by the chemicals phenol or sulphoraphen[2]. The X-ray-induced lethals used, all of which were studied cytologically, were found to involve no detectable chromosomal aberrations[3] and the spontaneous lethals, although not examined cytologically, probably also represent point mutations. Thus the finding of a similar distribution as to the time when these lethals and those produced by ultra-violet radiation exert their detrimental effects lends further support to our earlier interpretation that lethal point mutations exert their killing effect usually during the stages when many physiological functions new to the individual come into active operation for the first time in its life.

This work was supported by a grant from the U.S. Atomic Energy Commission.

I wish to express my appreciation to Dr. H. J. Muller for his interest and many helpful suggestions during the course of this work.

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Heat Therapy of Virus-infected Raspberries

Of the various techniques claimed to effect cure of virus-infected plants, only those involving heat treatments of plant material have given consistent results. Warm water treatments and exposure to high air temperature have been used by a number of workers to free plants from certain virus diseases, including raspberries infected with *Rubus* stunt[1].

The purpose of this communication is to describe a method that has been used successfully for freeing raspberries from certain aphid-transmitted viruses which differ from *Rubus* stunt. Material for treatment was drawn from virus-tested stocks of Norfolk Giant infected with leaf mottle virus, Malling Jewel with a mixture of viruses including leaf spot, and Malling Promise and Lloyd George (New Zealand stock) each infected with unidentified latent viruses[2,3]. Dipping whole canes and root cuttings in water at temperatures ranging from 35° C. to 50° C. for periods up to two hours failed to effect a cure. But in 1952 virus-free plants of Lloyd George and Malling Jewel were obtained by subjecting growing plants to an air temperature of 32° C. for periods of one to four weeks. After the treatments terminated, the plants were grafted to healthy plants of *Rubus henryi*, a species which is hypersensitive to infection with any of the known raspberry viruses[3]. Absence of symptoms in *R. henryi* is at present assumed to imply freedom from virus in the plant tested. The plants surviving from the first trials have twice been so tested and are still virus-free.

Since then the technique has been improved, and virus-free plants of all four varieties listed above have been obtained. Experiments were begun in June 1953 and are still continuing. Strongly growing plants in 5-in. pots were first defoliated and then packed in trays of damp peat moss and transferred to a square box of side 3 ft., electrically heated and thermostatically controlled to $\pm$ 0·5° C. Humidity was maintained by daily watering of the pots and peat, and light was supplied for seventeen hours daily by a 400-W. mercury-vapour lamp fitted over the roof of the box. Large plants were pruned to accommodate them more readily into the box. The apparatus was kept in a room not subject to marked temperature fluctuations.

During the first experiment the air temperature was maintained at 32° C. and successive batches of four plants of each of the varieties Norfolk Giant, Lloyd George, Malling Promise and Malling Jewel were exposed for 8, 10, 12, 16 and 20 days. All the plants survived. From the three lots of sixteen plants treated for 8, 10 and 12 days respectively, three, eight and five virus-free plants have so far been recovered; the results of the longer treatments are not yet known. In a second experiment the temperature was raised to 35° C. and the plants, then approaching dormancy, were cut down to about 6 in. After a few days treatment, young shoots appeared, and these continued to grow normally during the experiment. Again, all the plants survived for periods of up to 16 days; but the treatments terminated too late in the season for graft testing to be carried out.

No cures were effected in one earlier trial where plants were exposed for four days at 32° C., and the results so far suggest that exposures longer than eight days are necessary to give a high proportion of cures. The data are insufficient to establish whether there are differences in the resistance to heat treatment among the viruses present in the raspberry plants used, but this is being investigated.

Provided that heat-treated raspberry plants are not altered in other and more detrimental ways than in being freed from virus infection, the potentialities

of this technique for the ready production and maintenance of virus-free canes are obvious.

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Cuticles of Erupted Teeth

It is generally agreed that Nasmyth's membrane, which is present on the enamel surface of recently erupted teeth, is composed of an outer cellular and an inner structureless layer, and that shortly after eruption the cells are lost due to degeneration and masticatory trauma. Whether or not the inner structureless layer remains on the surface is a matter of controversy, but it may be inferred from recent papers that it does remain throughout life[1–3]. This, however, is difficult to envisage in view of the findings of Scott *et al.*[4] and Scott[5], who have demonstrated the wear which takes place continually on the enamel surface of erupted teeth, although it is true that these authors do speak of a 'cuticle'.

On the other hand, Manly[6], Vallotton[7] and Atkinson[8] have reported the formation of an amorphous membranous deposit on the enamel surface of erupted teeth. This suggests the possibility of confusion between two membranes of differing origin.

In agreement with Atkinson's findings an amorphous cuticle, resembling in appearance the inner structureless layer of Nasmyth's membrane, has been recovered from areas of enamel attrition as well as from the remaining enamel surface. However, on close examination two differences were observed. First, only the inner layer of Nasmyth's membrane exhibits interference phenomena, and secondly, this layer is marked by outcrops of the enamel prism ends grouped in lines typical of the unworn enamel surface, whereas the cuticle present on older erupted teeth is marked either faintly or not at all. Furthermore, the two membranes differ chemically. The cuticle of erupted teeth is more stable in strong acid at room temperature, and at boiling point it forms 'humin'. This, together with the positive reactions obtained with protein and carbohydrate tests, may indicate that the cuticle contains both these substances in combination. The nature of this combination is indicated by metachromatic staining with toluidine blue and by a positive periodic acid – Schiff reaction, suggesting that the cuticle may contain a mucoprotein. Lipoid is also demonstrable using sudan B.

In consequence of these observations, a series of experiments was carried out using the crown of a 'normal' caries-free tooth extracted from an adult. After removal of the cuticle by immersion in acid the tooth was fitted to a partial denture. This denture was worn in the mouth for periods varying from 7 to 63 days. At the end of each period a cuticle, which in all respects resembled the naturally occurring structure on the enamel of adult erupted teeth, was removed from the crown surface. It is interesting to note that this occurred in spite of the fact that some features of a vital tooth, such as those concerned with enamel permeability, were absent. Atkinson and Prophet[9] suggested that substances from the saliva might be involved in the formation of 'crack lamellæ'. In the present investigation the naturally occurring cuticle is found to be connected with such lamellæ, which show the same properties chemically (in contrast with developmental lamellæ obtained from unerupted teeth).

From these observations it appears evident that what in the past has been identified on adult erupted teeth as the inner structureless layer of Nasmyth's membrane has, in fact, been a cuticle formed, and capable of re-formation, after eruption. Bacteria are not found to be constituents of the cuticle.

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Divergence in Helical Polypeptide Chains and in Phyllotaxis

In the α-form of synthetic polypeptide chains (poly-*l*-alanine, poly-γ-methyl-*l*-glutamate) divergences of the individual amino-acid residues of 5/18, 8/29 or 13/47 corresponding to helix periods of 27 A., 43 A., or 70·4 A., are discussed[1,2]. The numerators of these figures remind one of the divergences of phyllotaxis, where 5/13, 8/21 and 13/34 are members of the

$$\text{phyllotaxis sequence } \frac{1}{2}\ \frac{1}{3}\ \frac{2}{5}\ \frac{3}{8}\ \frac{5}{13}\ \frac{8}{21}\ \frac{13}{34}\ \cdots$$

In this sequence the numerator and the denominator of every member is the sum of those of the two preceding members. Since this regularity applies also to the divergences discussed for the α-polypeptide helices, an extrapolation to hypothetical lower members of a similar sequence is possible. As a result the following

$$\text{helix sequence } \left(\frac{1}{3}\ \frac{1}{4}\ \frac{2}{7}\ \frac{3}{11}\right)\ \frac{5}{18}\ \frac{8}{29}\ \frac{13}{47}\ \cdots$$

is obtained. It is possible that higher members of this sequence might have a practical significance for polypeptide helices with long-range periods higher than 70·4 A. The lower extrapolated members, between brackets, have probably no real meaning; they are only mentioned to show that the discussed divergences are members of a very striking sequence, comparable to that in phyllotaxis.

The similarity is certainly due to the same geometrical cause, that is, as dense as possible an arrangement of identical objects along a helix. In the case of phyllotaxis these objects are the protuberances of the young leaves on the growing point in a bud, and in that of the polypeptide helices the amino-acid residues in the crystal lattice.

A. Frey-Wyssling

Department of General Botany,
Swiss Federal Institute of Technology,
Zurich. Jan. 7.

[1] Bamford, C. H., Brown, L., Elliott, A., Hanby, W. E., and Trotter, I. F., *Nature*, **173**, 27 (1954).
[2] Pauling, L., and Corey, R. B., *Nature*, **171**, 59 (1953), find 12·5/45 which is nearly 13/47.

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, March 29

PHYSICAL SOCIETY, ACOUSTICS GROUP (at the Royal Society of Arts, 6 John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Annual General Meeting. 6 p.m.—Mr. W. H. Tait: "Double Reeds: a Note on Their Design and Methods of Making Them".*

Tuesday, March 30

ROYAL SOCIETY OF ARTS, COMMONWEALTH SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Sir Arthur Porritt, K.C.M.G.: "Social Medicine in Australia and New Zealand".

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Mr. S. S. Carlisle: "Automatic Control in the Iron and Steel Industry".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Dr. D. W. Holder: "Interaction between Shock Waves and Boundary Layers and its Importance in High-Speed Flight".

Tuesday, March 30—Thursday, April 1

PHYSICAL SOCIETY (in the Department of Physics, University College, Dublin)—Spring Meeting—"High Energy Accelerators and Cosmic Rays".

Wednesday, March 31

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Mr. R. Hanbury Brown: "Radio Astronomy".

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the CHELSEA POLYTECHNIC CHEMICAL SOCIETY, at Chelsea Polytechnic, Manresa Road, London, S.W.3), at 7 p.m.—Mr. W. M. Lewis: "Science in Criminal Investigation".

Wednesday, March 31—Friday, April 2

CHEMICAL SOCIETY (at the University, Manchester)—Anniversary Meetings.

Wednesday, March 31

10.30 a.m.—Symposium on "Dynamic Stereochemistry".

Thursday, April 1

11.30 a.m.—Prof. H. J. Emeléus, F.R.S.: "Organometallic Compounds containing Fluorocarbon Radicals" (Liversidge Lecture).

Friday, April 2

11 a.m.—Presidential Address by Prof. C. K. Ingold, F.R.S.

Thursday, April 1

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. D. W. Henderson: "The Work of the Microbiological Research Department".

ASLIB (at the Royal Society of Arts, 8 John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Dr. Richard Offor: "History of the Inter-University Council for Higher Education in the Colonies".

INSTITUTE OF METALS, LONDON LOCAL SECTION (at 4 Grosvenor Gardens, London, S.W.1), at 6 p.m.—Annual General Meeting, followed by Discussion on "The Brittle Fracture of Metals".

Thursday, April 1—Monday, April 5

BRITISH PSYCHOLOGICAL SOCIETY (at the University, Nottingham).—Annual Conference.

Friday, April 2

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Annual General Meeting; at 7.30 p.m.—Dr. D. S. Morris: "Chloramphenicol".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—The Right Hon. Lord Rothschild, F.R.S.: "Spermatozoa".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN AGRICULTURAL BOTANY—The Secretary of University Court, The University, Glasgow (March 31).

ASSISTANT LECTURER (with a degree in agriculture or equivalent qualification, and sound experience in practical work, and, if possible, in teaching) IN AGRICULTURE, at the Cumberland and Westmorland Farm School, Newton Riggs, near Penrith—The Director of Education, 5 Portland Square, Carlisle (April 2).

LECTURER IN ORGANIC CHEMISTRY, A LECTURER IN PHYSICAL AND INORGANIC CHEMISTRY, an ASSISTANT (Grade B) IN PHYSICS, an ASSISTANT (Grade B) IN BIOLOGY, and an ASSISTANT (Grade B) IN CHEMISTRY, at Birkenhead Technical College—The Director of Education, Education Offices, 63 Hamilton Square, Birkenhead (April 2).

ENGINEERS (3) (with first- or second-class honours engineering degree (civil or mechanical)) in the Department of Scientific and Industrial Research, Forest Products Research Laboratory, Princes Risborough, Bucks, for investigations on timber strength, wood sawing and machining—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.99/53A (April 3).

LECTURER (with good university degree or equivalent, and with considerable teaching and industrial or research experience) IN AIRCRAFT STRUCTURES, to teach subject to final B.Sc. and H.N.C. standard—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (April 3).

MATHEMATICIAN (with at least H.S.C. (science) or equivalent) at the Ministry of Supply Guided Weapons Establishment, Aberporth, South Wales, to undertake responsibility for film reading and computation section, including interpretation of records, and investigation of new and modified analysis techniques—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.58/54A (April 3).

SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER (with first- or second-class honours degree or equivalent qualification, in physics, chemistry or metallurgy), for development work on carbon for nuclear reactors, involving structural studies of porous solids—The Establishment Officer, Atomic Energy Research Establishment, Harwell, Berkshire, quoting 2/103/70 (April 3).

EXPERIMENTAL OFFICER, Grade III (with degree or diploma in engineering, or equivalent qualifications, and several years experience in wind tunnel investigations related to aircraft or missile development) in the Department of Supply, Aeronautical Research Laboratories, Fishermen's Bend, Victoria, Australia, to carry out wind tunnel investigations related to the development of new aircraft and missile types—The Senior Representative (AP.11), Department of Supply, Australia House, Strand, London, W.C.2 (April 5).

PRINCIPAL SCIENTIFIC OFFICER (Supersonic Theory) (with a degree of high standard in mathematics, and extensive experience of theoretical work in supersonic aerodynamics and ability to direct the work of others) IN THE HIGH SPEED AERODYNAMICS LABORATORY, Department of Supply, Salisbury, South Australia, to initiate and be responsible for research, especially of a mathematical nature, in supersonic and transonic flow; and to exercise supervision over the work of other scientific staff and of a small computing "pool"—The Senior Representative (A.P.10), Department of Supply, Australia House, Strand, London, W.C.2 (April 5).

PHYSICIST or CHEMIST, Principal Scientific Officer grade (with first- or second-class honours degree or equivalent in physics or chemistry, and considerable research and development experience in the field of high polymers, particularly natural and synthetic rubbers) at the London Headquarters of the Ministry of Supply, for duties which will include initiation and progressing of research and development work on rubbers for Service purposes, and advice to Service Departments on technical applications of rubber—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.163/54A (April 10).

SENIOR LECTURER IN GEOGRAPHY at the Fourah Bay College, Sierra Leone (University of Durham)—The Secretary, Advisory Committee on Colonial Colleges, 1 Gordon Square, London, W.C.1 (April 12).

PHYSICAL CHEMIST (with a first- or second-class honours degree in physical chemistry or equivalent qualifications, and preferably with previous experience of chemistry of plastics and polymers) at the National Coal Board, Stoke Orchard, near Cheltenham, for work on chemical and physical changes in coal during carbonization—The National Coal Board, Central Research Establishment, Stoke Orchard, near Cheltenham, Glos, quoting TT/751 (April 15).

BRITISH COKE RESEARCH ASSOCIATION FELLOW (honours graduate in chemistry, physics, or applied science related to fuel technology), to work on the physical chemistry of carbon, under the direction of the Professor of Physical Chemistry—The Registrar, King's College, Newcastle-upon-Tyne (April 19).

ASSISTANT LECTURERS (2) IN PSYCHOLOGY—The Registrar, The University, Manchester (April 21).

SENIOR LECTURER IN PHYSICS—The Registrar, The University, Sheffield (April 21).

ASSISTANT LECTURER IN THE DEPARTMENT OF BIOCHEMISTRY—The Secretary, University College London, Gower Street, London, W.C.1 (April 22).

LECTURER, Grade II (with a degree in metallurgy, engineering or related science), IN INDUSTRIAL METALLURGY—The Registrar, The University, Edgbaston, Birmingham 15 (April 30).

LECTURER or ASSISTANT LECTURER IN ORGANIC CHEMISTRY at the University College of North Staffordshire—The Registrar, The College, Keele, Staffs (April 30).

MYCOLOGIST IN THE PLANT PATHOLOGY DEPARTMENT—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (April 30).

RESEARCH FELLOW IN PURE SCIENCE at the University of Durham—The Secretary, University of Durham, 38 North Bailey, Durham (April 30).

SENIOR and JUNIOR RESEARCH FELLOWS (with first- or second-class honours degree in an appropriate subject, and able to show evidence of a very high standard of ability in research) in Government Scientific Establishments, for research into subjects of importance to H.M. Government—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4300/54 (April 30).

UNIVERSITY LECTURERS or UNIVERSITY DEMONSTRATORS AT THE FACULTY OF ENGINEERING, University of Cambridge—The Secretary of the Appointments Committee, Engineering Laboratory, Cambridge (April 30).

ASSISTANT LECTURER IN PURE MATHEMATICS—The Registrar, University College, Hull (May 1).

ESSO STUDENTSHIP IN CHEMICAL ENGINEERING tenable in the Department of Chemical Engineering, University of Cambridge—The Secretary, Department of Chemical Engineering, Tennis Court Road, Cambridge (May 1).

LECTURER IN SOCIAL ANTHROPOLOGY—The Registrar, King's College, Newcastle-upon-Tyne (May 1).

PROFESSOR OF PHYSICS at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (South Africa, May 1).

Senior Research Officers (3) (preferably with specialized post-graduate training in a branch of science applied to agriculture) to take charge of sugar cane research in the main ecological divisions of the sugar cane area—The Director of Research, Sugar Research Department, Mandeville, Jamaica, British West Indies (May 7).

Lecturer in Physics at the University of New England, Armidale, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Australia, May 10).

Ellison Research Fellows (3) (graduates of British universities) for research in chemistry or physics—The Registrar, The University, Sheffield (June 1).

Lecturer (with a good honours degree in botany and research experience, preferably in genetics) in Botany, at the Imperial College of Tropical Agriculture, Trinidad, British West Indies—The Secretary, The Imperial College of Tropical Agriculture, 40 Norfolk Street, Strand, London, W.C.2 (June 30).

Assistant Lecturer, Grade B (with a good honours degree in physics or electrical engineering, and some research, industrial or teaching experience) in the Department of Applied Physics and Electrical Engineering, College of Technology and Commerce, Cardiff—The Director of Education, City Hall, Cardiff.

Biochemist (with at least a good second-class honours degree, with appropriate postgraduate experience) at the West African Fisheries Research Institute, Sierra Leone—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.197/194/01.

Geologist (with second-class honours degree, Division 1, in geology, or equivalent) in the Gold Coast Civil Service, for geological mapping, investigation of mineral deposits and water supplies, etc.—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.105/13/07.

Organic Chemist for fundamental research on the chemistry of cellulose and its derivatives, a Chemist (with a leaning towards physical and/or analytical chemistry) for fundamental research in cellulose chemistry, a Physical Chemist to study the degree of polymerization of macromolecular substances, with ultra-centrifuge, etc., a Chemist or Physicist (with a knowledge of X-ray crystallography) for research on the structure of textile fibres, a Chemist (with experience in infra-red spectroscopic techniques) for research on the structure of textile fibres and on the mechanism of dyeing, a Chemist for fundamental and technical research on the bleaching of textiles, and a Chemist for fundamental and technical research on the chemical finishing of textiles, with the British Cotton Industry Research Association—Dr. F. C. Toy, Director of Research, Shirley Institute, Didsbury, Manchester 20.

Physicists (with good honours degree, and with some experience or training in research, not necessarily textile research) for work on textile problems—The Secretary, British Rayon Research Association, Barton Dock Road, Urmston, Manchester.

Principal Scientific Officers (with at least a second-class honours degree in physics or engineering, and with three years post-graduate research experience, and a knowledge of fluid dynamics) at the Department of Atomic Energy, Capenhurst, near Chester, as project leaders on engineering physics problems connected with gaseous diffusion plant and power reactors—The Department of Atomic Energy, Industrial Group Headquarters, Risley, Warrington, quoting 558.

Protozoologist (with a medical or veterinary degree or diploma registrable in the United Kingdom, and two years postgraduate research experience, and a sound knowledge of protozoology) at the East Africa Tsetse and Trypanosomiasis Research and Reclamation Organization, to undertake research in the human and animal trypanosomes—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.195/198/01.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Ministry of Agriculture and Fisheries. Report of the Working Party on Agricultural Education. Pp. 20. (London: H.M. Stationery Office, 1953.) 9*d*. net. [251

Microbes and Antimicrobial Agents in Vitro Microbiological Assay. (Paper Discs for use in Bacterial Sensitivity Tests.) Pp. 20. (Poole: British Drug Houses, Ltd., 1953.) [261

The Manchester Museum, The University, Manchester. Report 1952–1953. Pp. 24. (Manchester: Manchester Museum, 1954.) [261

Current Chemical Papers. 1954, No. 1. Pp. 44. (London: The Chemical Society, 1954.) [261

Proceedings of The Royal Society of Edinburgh. Series A (Mathematics). Vol. 64, Part 1 (No. 2): Asymptotic Renewal Theorems. By Walter L. Smith. Pp. 9–48. 6*s*. 9*d*. Vol. 64, Part 1 (No. 3): The Problem of Two Bodies in Whitehead's Theory. By Dr. G. L. Clark. Pp. 49–56. 1*s*. 3*d*. (Edinburgh and London: Oliver and Boyd, Ltd., 1954.) [261

University of Cambridge: School of Agriculture Memoirs. Memoir No. 25: A summary of the papers published by the members of the Staff of the School of Agriculture and its Associated Research Organizations during the period Oct. 1st, 1952—Sept. 30th, 1953. Review Series No. 8: Animal Production Research at Cambridge. By Dr. John Hammond, F.R.S. Pp. 31. (Cambridge: University of Cambridge, School of Agriculture, 1954.) 2*s*. 6*d*. [271

Ministry of Fuel and Power. Reports of H.M. Inspectors of Mines under the Coal Mines Act, 1911, for the year 1952. West Midland and Southern Division. By H. S. S. Scott. Pp. ii+20. (London: H.M. Stationery Office, 1954.) 1*s*. net. [22

University of London. University College Annual Report 1952–1953. Pp. 92. (London: University of London, 1954.) [22

Other Countries

Transactions of the National Institute of Sciences of India. Vol. 3, No. 5: Gaseous Reduction of Iron Ore. By Dr. H. Trivedi. Pp. 211–256. (New Delhi: Manager of Publications, 1953.) 3 rupees. [191

Centre National de la Recherche Scientifique. Centre d'Études Mathématiques en vue des Applications. Monographies. C: Physique Mathématique, 2: Les fonctions orthogonales dans les problèmes aux limites de la physique mathématique. Par Theodore Vogel. Pp. 192+4. (Paris: Éditions du Centre National de la Recherche Scientifique, 1953.) 1200 francs. [201

Les applications de la mécanique ondulatoire a l'étude de la structure des molécules. Réunions d'études et de mises au point, tenues sous la presidence de Louis de Broglie. Pp. 224+2 plates. (Paris: Éditions de la *Revue d'Optique et Instrumentale*, 1953.) 1600 francs. [201

Department of Scientific and Industrial Research, New Zealand. The Dominion Laboratory. Pp. 32 (13 plates). (Wellington, N.Z.: Department of Scientific and Industrial Research, 1953.) [261

The Use of Aircraft in Agriculture in the U.S.A. (Technical Assistance Mission No. 107.) Pp. 106. (Paris: Organization for European Economic Co-operation, 1953.) [261

Det Norske Videnskaps-Akademi I Oslo. Astrophysica Norvegica. Vol. 5, No. 3: On the Formation of Surface Waves in a Fluid Flowing over a Corrugated Bed and on the Development of Mountain Waves. By Enok Palm. Pp. 61–130. (Oslo: Jacob Dybwad, 1953.) [261

Smithsonian Institution. Proceedings of the United States National Museum. Vol. 103, No. 3322: The Fresh-Water Triclads (Turbellaria) of Alaska. By Roman Kenk. Pp. 163–186+plates 6–8. (Washington, D.C.: Government Printing Office, 1953.) [261

U.S. Department of Agriculture. Farmers' Bulletin No. 1651: The Corn Earworm as an Enemy of Field Corn in the Eastern States. By R. A. Blanchard and W. A. Douglas. Pp. 16. (Washington, D.C.: Government Printing Office, 1953.) 10 cents. [261

Bulletins de la Société Royale de Zoologie d'Anvers. No. 1: Les Infections à Plasmodium chez les Pingouins. Par Dr. J. Rodhain. Pp. 24 (4 plates). No. 2: Les Poissons d'Aquarium du Congo Belge. Par Dr. Max Poll. Pp. 48 (23 plates). No. 3: Les Facteurs Physio-Pathologiques Influencant l'Acclimatation de l'Okapi. Par Dr. L. M. G. Geurden. Apercu Succint de nos Connaissances Actuelles au sujet de l'Okapi. Par Dr. A. Vandermander. l'Acclimatation des Okapis à Londres et Copenhague. (Extriats de rapports de M.M. C. S. Webb, Curator of Mammals and Birds, Zoological Society of London, et Axel Reventlow, Adm. Director, Zool., Have Københavns. Pp. 54 (11 plates). (Anvers: Société Royale de Zoologie d'Anvers, 1953.) [261

Sudan Government. Wellcome Chemical Laboratories, Medical Services, Ministry of Health, Khartoum. Report of the Government Analyst for the period 1.7.1952–30.6.1953. Pp. 24. (Khartoum: Ministry of Health, 1953.) [261

Imperial College of Tropical Agriculture. A Report on Cacao Research, 1952. Pp. 72. (St. Augustine, Trinidad and London: Imperial College of Tropical Agriculture, 1953.) 8*s*. [261

Organisation for European Economic Co-operation. Summary of the First Annual Programme of Action of the European Productivity Agency. Pp. 18. (Paris: Organisation for European Economic Co-operation, 1954.) [261

Institute for Weather and Climate Research. The Norwegian Academy of Sciences and Letters. Publication No. 1, 1953: Two-Dimensional Perturbation of a Flow with Constant Shear of a Stratified Fluid. By A. Eliassen, E. Høiland and R. Riis. Pp. 30. Publication No. 2, 1953: A Statistical Discussion of a Possible Connection Between Solar Activity and Sea-Level Pressure. By Jack Nordo. Pp. 42. (Blindern–Oslo: Institute of Theoretical Astrophysics, 1953.) [261

State of California: Department of Fish and Game. Marine Research Committee. Progress Report, 1 July 1952 to 30 June 1953. Pp. 44. (Terminal Island, Calif.: State Fisheries Laboratory, 1953.) [261

Berichte des Deutschen Wetterdienstes. Nr. 6: Klimatologische Studie über die Temperaturverhältnisse der Grosswetterlagen Mitteleuropas am Beispiel von Karlsruhe und Bremen. Von Dr. Kurt Bürger. Pp. 46. Nr. 7: Statistiche Untersuchungen über die Zirkulation der Westdrift in 55° Breite. Von Dr. Oskar Essenwanger. Pp. 22. 2.90 D. marks. Nr. 8: Uber die Messung des Luftdrucks durch Bestimmung der Siedetemperatur mit dem Hypsometer. Von Dr. Hans Gerhard Müller. Pp. 14. (Bad Kissingen: Deutschen Wetterdienstes, 1953 and 1954.) [261

Proceedings of the Kjeller Conference on Heavy Water Reactors, Organized by the Joint Establishment for Nuclear Energy Research, held at Kjeller and Oslo, August 11th to 13th 1953. Edited by J. A. Goedkoop and G. Jenssen. (No. 7, JENER Publication.) Pp. xi+238. (Kjeller per Lillestrøm: Joint Establishment for Nuclear Energy Research, 1953.) 35 kroner. [261

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